

FINAL WORK PLAN

**Technology Application for Enhanced *In-Situ*
Bioremediation of Chlorinated Aliphatic
Hydrocarbons via Organic Substrate Addition for
The North Lobe of the Former AOC-2 TCE Plume,
Naval Air Station Fort Worth Joint Reserve Base, Texas**



U.S. AIR FORCE

Prepared For

**Air Force Center for Environmental Excellence
Technology Transfer Division
San Antonio, Texas**

and

**Naval Air Station Fort Worth Joint Reserve Base
Fort Worth, Texas**

July 2003

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TECHNOLOGY APPLICATION FOR ENHANCED *IN SITU* BIOREMEDIATION OF CHLORINATED ALIPHATIC HYDROCARBONS VIA ORGANIC SUBSTRATE ADDITION FOR THE NORTH LOBE OF THE FORMER AOC-2 TCE PLUME, NAVAL AIR STATION FORT WORTH JOINT RESERVE BASE, TEXAS

July 2003

Prepared For:

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
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ACRONYMS LIST

ACC	Air Combat Command
AFCEE/ERS	Science and Technology Division of the Air Force Center for Environmental Excellence
AFB	Air Force Base
AFP4	Air Force Plant 4
AFRPA	Air Force Real Property Agency
AOC	Area of Concern
amsl	above mean sea level
bgs	below ground surface
Br ⁻	bromide ion
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAHs	chlorinated aliphatic hydrocarbons
CaCO ₃	calcium carbonate
CH2MHill	CH2MHill Constructors
cm/sec	centimeter per second
DCE	dichloroethene
DO	dissolved oxygen
ERA	Environmental Restoration Account
ESE	Environmental Science and Engineering, Inc.
ESTCP	Environmental Security Technology Certification Program
FRTR	Federal Remediation Technologies Roundtable
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet/year
gpd/ft	gallons per day per foot
gpd/ft ²	gallons per day per square foot
gpm	gallons per minute
GMW	groundwater monitoring well
HDPE	high density polyethylene
ID	inside diameter
IDW	investigation-derived waste
ITRC	Interstate Technology Regulatory Cooperation
iron (II)	ferrous iron
iron (III)	ferric iron
IRP	Installation Restoration Program
Jacob	Jacob Engineering Group, Inc.
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
µm	micrometer
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
MDL	method detection limit
MNA	monitored natural attenuation
mV	millivolt
N	nitrogen

NaBr	sodium bromide
NAPL	non-aqueous phase liquid
NAS Fort Worth	Naval Air Station Fort Worth Joint Reserve Base
OD	outside diameter
ORP	oxidation-reduction potential
Parsons	Parsons Engineering Science, Inc.
PCE	tetrachloroethene
PID	photoionization detector
PLFAs	phospholipid fatty acids
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RL	reporting limit
SAC	Strategic Air Command
SIW	substrate injection well
SWMU	solid waste management unit
TCA	trichloroethane
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
TMBs	trimethylbenzenes
TNRCC	Texas Natural Resource Conservation Commission
TOC	total organic carbon
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USN	United States Navy
USCS	Unified Soils Classification System
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VFAs	volatile fatty acids
VMW	soil vapor monitoring well
VOCs	volatile organic compounds
WWII	World War II

SECTION 1

INTRODUCTION

This work plan was prepared by Parsons Engineering Science, Inc. (Parsons) for the Air Force Center for Environmental Excellence, Environmental Science and Technology Division (AFCEE/ERS) and Naval Air Station Fort Worth Joint Reserve Base (NAS Fort Worth), Texas. Activities conducted during this project will be preformed under Air Force Contract F41624-00-D-8024, Task Order 11.

1.1 PILOT TEST OBJECTIVES

This study is being conducted as a technology demonstration to evaluate the effectiveness of vegetable oil injection to remediate chlorinated aliphatic hydrocarbons (CAHs, commonly referred to as chlorinated solvents) in groundwater at NAS Fort Worth. This work plan describes a pilot test for distributing a low-cost, slowly soluble, organic substrate into the Terrace Alluvium unconfined aquifer to enhance the *in situ* reductive dechlorination of CAHs via vegetable oil injection in the Northern Lobe of the Area of Concern (AOC-2) TCE Plume (hereafter referred to as the North Lobe) in the vicinity of monitoring well WCHMHTA010 (Figure 2.2).

The pilot study is designed to stimulate reductive dechlorination of CAHs by injecting the organic substrate into a treatment zone within the contaminated aquifer of the North Lobe. The addition of an organic substrate stimulates indigenous microbial growth and development. Biodegradation of the substrate produces metabolic acids and lowers the oxidation-reduction potential (ORP) of the aquifer, thereby stimulating anaerobic conditions conducive to reductive dechlorination. Fermentation of the organic material (primarily metabolic acids such as propionic acid, butyric acid, and acetic acid) produces molecular hydrogen, which is the primary electron donor used by dechlorinating bacteria for reductive dechlorination of CAHs. Therefore, the addition of the vegetable oil substrate at the North Lobe will ultimately enhance the rate of sequential reductive dechlorination of tetrachloroethene (PCE) to trichloroethene (TCE) to dichloroethene (DCE) to vinyl chloride (VC) and finally to innocuous end products including ethene, ethane, carbon dioxide, and water.

The results of this pilot test will serve to provide valuable data to support an evaluation of the restoration potential of the North Lobe by providing direct evidence to demonstrate whether carbon substrate addition technologies are capable of remediating groundwater contamination at the North Lobe effectively, reliably, and within a reasonable time frame. This study will produce design critical data which could be used to design a full scale vegetable oil remedial application. Cost and performance data will

also be collected and evaluated during the course of this pilot test. The following guidance documents will be used to collect and evaluate cost and performance data:

- Interstate Technology Regulatory Cooperation (ITRC), 1997;
- Environmental Security Technology Certification Program (ESTCP), 1998;
- Federal Remediation Technologies Roundtable (FRTR), 1998; and
- ESTCP, 2002.

The activities associated with this project will be performed in accordance with the *AFCEE Model Field Sampling Plan* (AFCEE, 1997), the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (United States Environmental Protection Agency [USEPA], 1998) and the *Draft Field Feasibility Test for In-Situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection* (Parsons, 2001).

1.2 DOCUMENT ORGANIZATION

This work plan is divided into six sections including this introductory section. A review of the site history, background information, and site characteristics is presented in Section 2. Section 3 describes the process by which biodegradation of chlorinated solvents occurs, and how biodegradation can be enhanced by the addition of vegetable oil as an organic substrate. Procedures for conducting and evaluating the results of the proposed vegetable oil pilot test are discussed in Section 4. A tentative schedule for conducting the pilot test and evaluating the results is presented in Section 5. The references cited in this document are listed in Section 6.

SECTION 2

SITE DESCRIPTION

2.1 BACKGROUND INFORMATION

2.1.1 Site Description and Operational History

The following subsections pertaining to NAS Fort Worth site description, history, geology, and hydrogeology are paraphrased from CH2M Hill Constructors Incorporated (CH2M Hill), 2000 and HydroGeoLogic, 2000.

Prior to 1941 the area that is now occupied by NAS Fort Worth consisted of woods and pasture land in an area known as White Settlement. In August 1942, the base was opened as Tarrant Field Airdrome. The original mission of Tarrant Field was to train Army Air Corps pilots to fly the B-24 Liberator medium bomber. At the time the B-24 Liberators were being constructed by the Consolidated Aircraft Corporation in a manufacturing facility that is now known as Air Force Plant 4 (AFP4).

Construction of the airfield and supporting hangers and other structures continued into 1943. In May 1943, the airfield was re-designated as Fort Worth Army Air Field. The primary mission of Fort Worth Army Air Field continued to be the training of bomber crews through the end of World War II (WWII), with transition to the B-32 bomber in January 1945 and a transition to the B-29 bomber at the end of 1945. After the end of WWII, Fort Worth Army Air Field became the home of the 7th Bombardment Group.

The Strategic Air Command (SAC) assumed command of the facility in 1946. Fort Worth Army Air Field was renamed Carswell Air Force Base (AFB) soon after in 1948 when the Army Air Corps became the United States Air Force (USAF). The SAC mission remained at Carswell AFB until 1992, when Air Force reductions resulted in the closure of the Base. After the Base was closed, the Air Combat Command (ACC) assumed control of the Base and its facilities. In October 1994, the United States Navy (USN) assumed responsibility for the facility. Officers, personnel, and equipment from Carswell AFB and Naval Air Stations in Dallas Texas, Memphis Tennessee, and Glenview Illinois, were combined to streamline the naval facilities budget and to place key personnel and equipment in one central location. Soon after the USN assumed control of Carswell AFB, the facility was renamed NAS Fort Worth. The location of NAS Fort Worth is depicted on Figure 2.1.

The latest information available (CH2M Hill, 2000) indicates that approximately 400 officers, 1,400 civil employees, 1800 active reservists, and 125 assorted aircraft are based at NAS Fort Worth. NAS Fort Worth functions as a self-sustaining community, with its

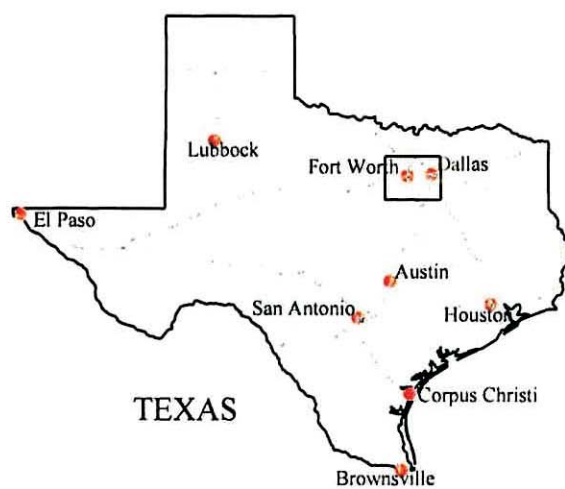


FIGURE 2.1

SITE

LOCATION MAP

Substrate Injection Pilot Test
Area of Concern 2
NAS Fort Worth JRB, Texas

PARSONS

Denver, Colorado

own fire department, police department, public works department, air terminal, medical clinic, gas stations, and numerous training and maintenance facilities.

2.1.2 NAS Fort Worth Regulatory History

The Installation Restoration Program (IRP) was initiated at NAS Fort Worth (Carswell AFB at the time) with a Phase I records search to identify past waste disposal activities that may have resulted in contaminant release to the environment. Seventeen on-Base and five off-Base sites were identified as requiring further evaluation (CH2M Hill, 1984). The 22 identified sites were ranked based on environmental setting, past waste disposal practices, and contaminant migration potential. Ten of these sites were subsequently determined not to pose a significant threat to human health or the environment.

The remaining 12 sites were targeted for Phase II confirmation and quantification investigations (Radian, 1986 and 1989). In 1989, the USEPA conducted the Preliminary Review/Visual Site Inspection portions of a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) for NAS Fort Worth (USEPA, 1989). A hazardous waste permit (HW-50289) was issued to the Base by the Texas Resource and Conservation Commission (TNRCC) in 1991.

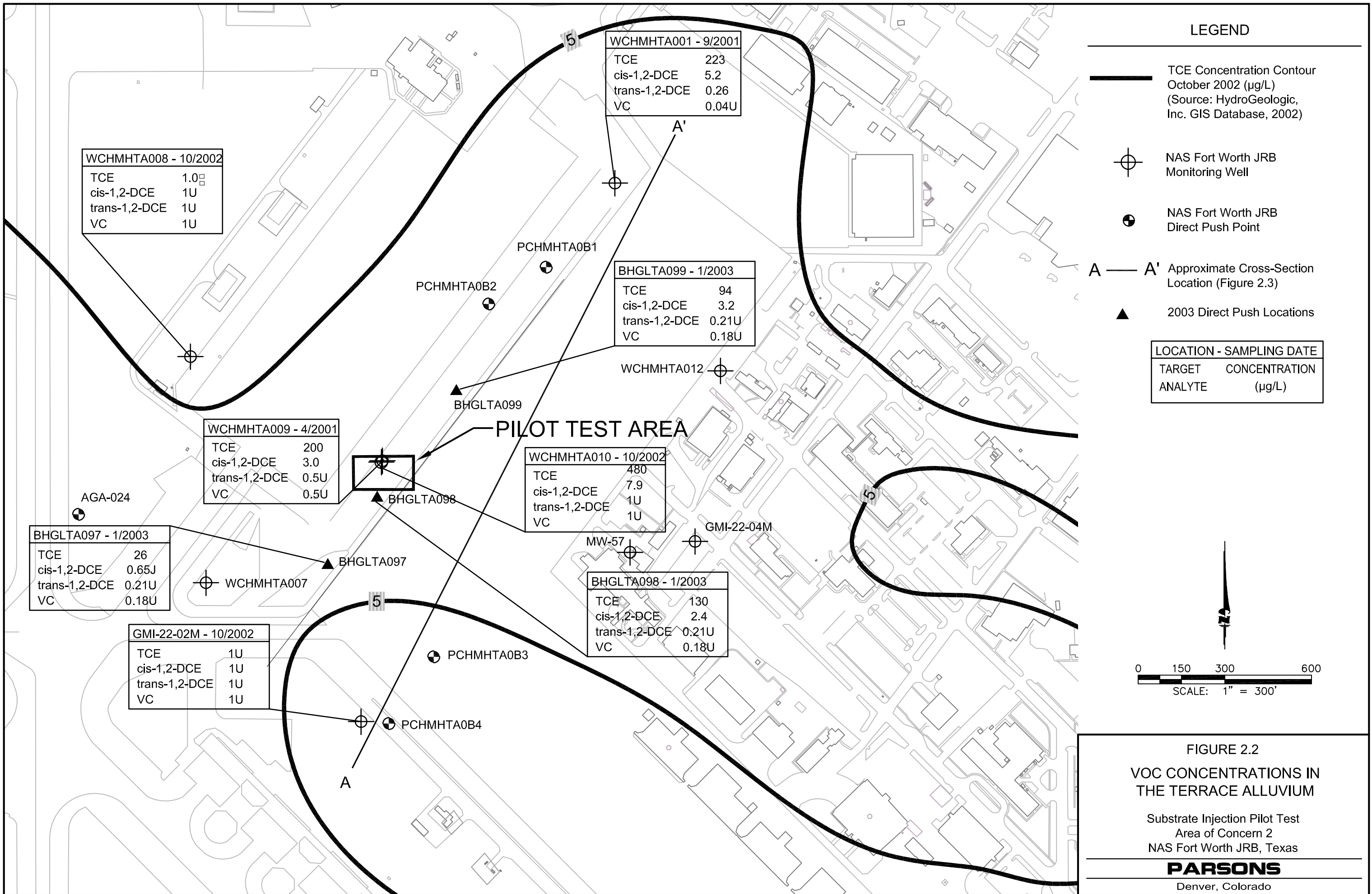
Sixty eight solid waste management units (SWMUs) and 15 AOCs were identified as of November 2000. Sites that are considered to be off-Base (as a result of Base closure activities) are being managed by AFCEE under Air Force Real Property Agency (AFRPA), while sites on-Base are being managed by AFCEE under the Environmental Restoration Account (ERA). Since 1990, site-specific investigations have been conducted at various SWMUs and AOCs to support remediation and/or closure activities.

The AOC-2 plume was known as the air field groundwater plume and was defined as all areas on NAS Fort Worth where TCE is detected in groundwater (CH2M Hill, 2000). The AOC-2 Plume was recently closed from a regulatory standpoint. Thus, this plume will hence forth be referred to as the Former AOC-2 Plume. The area within the AOC-2 TCE plume where the pilot test will be conducted is generally referred to as the northern lobe of the TCE plume and will be referred to as the North Lobe. The North Lobe of the former AOC-2 TCE plume is depicted on Figure 2.2.

2.2 SITE SETTING

In order to develop a synopsis the North Lobe pilot test area physical characteristics, data from the following sources are included:

- *Final Basewide Groundwater Sampling and Analysis Program, 1999 Annual Report* (HydroGeoLogic 2000); and
- *Final RCRA Facility Investigation Report Area of Concern 2, NAS Fort Worth, JRB Texas* (CH2M Hill, 2000).
- AFCEE Help Desk, Data package compiled from various contractors (AFCEE Help Desk, 2003).



2.2.1 Land Use, Physiography, and Climate

Prior to 1941, the area now occupied by NAS Fort Worth consisted of woods and pasture land. The area currently surrounding NAS Fort Worth is industrial and residential/light commercial. The west fork of the Trinity River flows along part of the northern and eastern boundaries of NAS Fort Worth, and is dammed to form Lake Worth. Lake Worth is a water supply and recreational reservoir which borders NAS Fort Worth to the north. The residential communities of River Oaks and Westworth Village lie to the east and south of the Base. The west side of the Base is bounded by AFP4 and the community of White Settlement.

NAS Fort Worth is located in the Grand Prairie Section of the Central Lowlands Physiographic Province of Texas. The area is characterized by broad, gently rolling plains with moderately sloping terraces of sedimentary rock outcrops. These plains are covered by variable thicknesses of loamy soil upon which grasslands have developed. Isolated stands of upland timber are found in areas where no agricultural activity has occurred within the past several decades.

Ground surface elevations at NAS Fort Worth range from approximately 590 feet above mean sea level (amsl) along the southern shore of Lake Fort Worth to approximately 600 feet amsl in the southwestern corner of the Base. The existing topography of this area has been controlled by natural process and human activities. Surface water erosion related to Farmers Branch Creek and the West Fork of the Trinity River has created the existing topographic relief. Site development and grading operations since the 1940s have resulted in a relatively uniform ground surface elevation over the majority of the Base.

The climate in the Fort Worth area is sub-humid with mild winters and hot, humid summers. The average precipitation is approximately 32 inches per year, with the majority falling between April and October.

2.2.2 Regional Geology and Hydrogeology

The geologic and hydrogeologic system at NAS Fort Worth consists of three primary geologic units. From shallowest to deepest, the units beneath NAS Fort Worth are: Terrace Alluvium, the Walnut Formation, and the Paluxy Formation. This substrate injection pilot test will be confined to the Terrace Alluvium and the uppermost portion of the Walnut Formation. Therefore, the following geology and hydrogeology discussion is limited to these formations.

2.2.2.1 Terrace Alluvium

The Terrace Alluvium is the upper most water-bearing stratigraphic unit beneath NAS Fort Worth. This unit underlies unconsolidated fill and is composed of Quaternary alluvial deposits.

The overlying fill has been deposited on the ground surface during construction activities over much of the developed portions of the base since the 1940's. The fill material generally consists of reworked Terrace Alluvium as well as material imported from off-Base sources. Fill materials at NAS Fort Worth generally consist of variable

mixtures of sand, silt, and gravel. In the landfill areas, the fill materials are combined with general refuse including construction debris, and chemical waste (Jacob Engineering Group, Inc. [Jacob], 1996).

The Terrace Alluvium is highly heterogeneous in both the lateral and vertical directions and is comprised of interbedded clay, silt, and poorly to moderately sorted sand and gravel. Basal gravel and weathered limestone is frequently found at the contact between the Terrace Alluvium and the underlying Walnut Formation.

Within the North Lobe study area, the thickness of the Terrace Alluvium and fill material ranges from 0 to 40 feet, depending on the presence or absence of paleochannels eroded into the underlying bedrock. The depth to the top of bedrock is highly variable over the North Lobe area, ranging from 11 to 20 ft below ground surface (bgs) in the eastern portion of the North Lobe (United States Army Corps of Engineers [USACOE], 1992, Law, 1995) to 30 to 40 feet bgs in the western portion of the North Lobe (USACOE, 1992, Environmental Science and Engineering [ES&E], 1994).

The saturated thickness of the Terrace Alluvium is generally greatest along the axes of the two paleochannels existing beneath NAS Fort Worth (United States Geological Survey [USGS], 1996; Rust Geotech, 1996). One paleochannel extends southeast from the assembly building and East Parking Lot toward the golf course (Rust Geotech, 1996; Parsons, 1996). The second paleochannel is believed to trend northeast from the East Parking Lot to the flightline. The northeast paleochannel appears to bifurcate along the flightline, part of it continuing north toward Lake Worth, and part of it trending east toward and beyond the Alert Apron Area (Parsons, 1998). The paleochannels represent conduits of material that is significantly more transmissive than the surrounding materials. Therefore, it is likely that the majority of the groundwater flow through this area is occurring within the paleochannels. The pilot test system will be installed in the northeast paleochannel, in the vicinity of monitoring well WCHMHTA010 in an effort to intercept groundwater flow and degrade contaminant mass flowing through the paleochannel.

Recharge to the Terrace Alluvium Aquifer occurs through the infiltration of precipitation and surface water. Extensive on-Base pavement and construction restricts this downward migration. Additional recharge, however, comes from the leakage and infiltration of water from water supply lines, sewer lines, storm drains, cooling water systems, and fire fighting lines (HydroGeoLogic, 2000). Groundwater in the Terrace Alluvium Aquifer generally flows east and southeast from AFP4, and discharges as basal flow to the west fork of the Trinity River, Farmers Branch Creek, King Branch Creek, and Lake Worth (CH2M Hill, 2000).

The estimated hydraulic conductivity of the Terrace Alluvium groundwater is approximately 4.6 gallons per day per square foot (gpd/ft²) (Radian, 1989). Hydraulic gradient, hydraulic conductivity, transmissivity, estimated porosity, and average linear groundwater flow velocity data collected from the Terrace Alluvial flow system by CH2M Hill are summarized in Table 2.1 (CH2M Hill, 2000). Local hydraulic gradients in the Terrace Alluvium are variable, but historically range from 0.004 to 0.2 feet per foot (ft/ft) (ES&E, 1994), reflecting variations in the lithologic character of the unconsolidated sediments and weathered bedrock and localized recharge. Historic

hydraulic conductivities in the Terrace Alluvium groundwater (easterly-flowing) ranged from 1.97×10^{-2} to 9.76×10^{-6} centimeters per second (cm/s), with mean hydraulic conductivity of 4.52×10^{-4} cm/s based on a sampled population of 13 monitoring wells (Rust Geotech, 1996). Estimated transmissivities range from 5 to 260 gallons per day per foot (gpd/ft), and tend to be higher in areas of greater saturated thickness. Average linear groundwater velocities in the Terrace Alluvial flow system were estimated based on calculated hydraulic gradients, calculated hydraulic conductivity, and assumed porosity by Rust Geotech in 1996. The estimated average groundwater flow velocities calculated by Rust Geotech ranged from 7 to 22 feet per year (ft/yr) (Rust Geotech, 1996). Groundwater flow velocities calculated from hydraulic data collected by CH2M Hill (Table 2.1) range from 72 ft/yr to 425 ft/yr with an average groundwater flow velocity of 290 ft/yr. These data indicate that the groundwater flow velocity within the Terrace Alluvium is highly variable across the Base. This variability is likely due to local stratigraphic and groundwater gradient changes. A conservative estimated groundwater flow rate of approximately 150 ft/yr was used to design this substrate addition pilot test.

2.2.2.2 Walnut Formation

The Walnut Formation (0.5 to 30 feet thick) consists of gray claystone and limestone containing shell conglomerates, clay, and black fissile shale. The Goodland and Walnut formations are not generally distinguished from each other in lithologic logs from previous investigations. The thickness of these combined units range from 0.5 to 70 feet thick beneath NAS Fort Worth (ES&E, 1994; USGS, 1996).

The Walnut aquitard represents a low permeability zone which hydraulically separates the Terrace Alluvium Aquifer from underlying water bearing units. The primary inhibitors to vertical groundwater movement within these units are the fine-grained clay and shale layers that are interbedded with layers of limestone.

Some groundwater movement does occur within the Walnut Aquitard, but vertical groundwater movement is extremely slow with vertical hydraulic conductivities ranging between 1.2×10^{-9} cm/s and 7.3×10^{-11} cm/s (ES&E, 1994). The logarithmic mean of vertical hydraulic conductivity values collected from core samples of the Walnut Formation (Radian, 1991) was calculated to be 7.0×10^{-10} cm/s. This corresponds to a vertical advective flow velocity of between 1.2×10^{-3} feet per day (ft/day) and 5.2×10^{-3} ft/day (ES&E, 1994). Hydrographs from paired monitoring wells installed in the Terrace Alluvium and the Paluxy Formation indicate that there is minimal flow from the Terrace Alluvium Aquifer to the Paluxy Aquifer in areas where the Walnut Formation has not been significantly eroded (USGS, 1996).

2.2.3 North Lobe Geology and Hydrogeology

Site Geology is limited to geologic boring log data collected during the installation of monitoring wells WCHMHTA009 and WCHMHTA010.

TABLE 2.1
TERRACE ALLUVIUM HYDRAULIC CONDUCTIVITIES AND GROUNDWATER VELOCITIES
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Monitoring Well	Test Date	Screened Interval Elevation (ft bgs) ^{a/}	Test Number	Hydraulic Conductivity (K)			Estimated Effective Porosity	Hydraulic Gradient (ft/ft) ^{c/}	Average Groundwater Velocity (ft/yr) ^{f/}
				(ft/day) ^{b/}	(cm/sec) ^{c/}	(gpd/ft ²) ^{d/}			
Terrace Alluvium									
CG39-B97-43S	Aug-97	30.0-35.0	1	18	6.4E-03	135	0.20	0.006	198
			2	28	1.0E-02	212	0.20	0.006	311
			3	16	5.5E-03	117	0.20	0.006	171
			Average	21	7.3E-03	155	0.20	0.006	227
2-355B	Aug-97	19.9-29.9	1	7.7	2.7E-03	57	0.20	0.006	84
			2	6.5	2.3E-03	49	0.20	0.006	72
			Average	7.1	2.5E-03	53	0.20	0.006	78
WCHMHTA007	Jan-98	12.5-32.5	1	51	1.8E-02	384	0.20	0.006	561
WCHMHTA009	Jan-98	4.5-12.0	1	11	4.0E-03	85	0.20	0.006	124
WCHMHTA010	Jan-98	12.0-22.0	1	39	1.4E-02	290	0.20	0.006	425
WCHMHTA011 ^{g/}	Jan-98	12.0-22.0	1	229	8.1E-02	1710	0.20	0.006	2503
WCHMHTA012	Jan-98	8.5-18.5	1	39	1.4E-02	288	0.20	0.006	422
GMI-22-02M	Jan-98	5.5-30.5	1	11	3.8E-03	80	0.20	0.006	118
GMI-22-04M	Jan-98	13.0-23.0	1	34	1.2E-02	252	0.20	0.006	369
Average of Terrace Alluvium:				27	9.4E-03	198	0.20	0.006	290

^{a/} ft bgs = feet below ground surface.

^{b/} ft/day = feet per day.

^{c/} cm/sec = centimeters per second.

^{d/} gpd/ft² = gallons per day per square foot.

^{e/} ft/ft = foot per foot.

^{f/} ft/yr = feet per year.

^{g/} Data from well WCHMHTA011 were not considered in averaging calculations.

The stratigraphy in the vicinity of WCHMHTA009 and 010 generally follows the stratigraphic relationships presented above in Section 2.2.2. In this area, approximately 24 feet of Terrace Alluvium soils unconformably overlies shale and limestone bedrock of the Walnut Formation. The Terrace Alluvium soils consist of approximately six feet of sandy clay underlain by approximately 10 feet of sandy gravel. The sandy gravel is in turn underlain by eight feet of sand. The shallow subsurface stratigraphy in the vicinity of WCHMHTA009 and 010 is depicted on Figure 2.3.

2.2.4 Groundwater Use

In some parts of Tarrant County, primarily in those areas adjacent to the Trinity River, groundwater from the Terrace Alluvium aquifer is used for irrigation and residential use (HydroGeoLogic, 2000). However, groundwater from the Terrace Alluvium Aquifer is not often used as a source of potable water due to limited distribution, poor yield, and susceptibility to surface/storm water pollution (USGS, 1996). No potable water supply wells are completed in the Terrace Alluvium Aquifer within approximately 0.5 miles of NAS Fort Worth (HydroGeoLogic, 2000).

2.2.5 Potential Pathways and Receptors at North Lobe

The North Lobe groundwater contamination is located on a secured military Base, therefore Base workers are the most probable potential receptors that could be exposed to any site-related contamination.

2.3 NATURE AND EXTENT OF CONTAMINATION

This pilot study will focus on remediating chlorinated solvent contaminated groundwater within the Terrace Alluvium unconfined aquifer. Therefore, the nature and extent discussion in the following sub-sections will focus on soil and groundwater contaminant concentrations detected within the Terrace Alluvium.

2.3.1 Contaminants in Soil

In 1997, a total of 19 soil samples were collected during the North Lobe RCRA Facility Investigation (RFI) field effort by CH2M Hill. Thirteen soil samples were collected from 11 of the borings installed for groundwater monitoring with one sample collected at each boring. Samples were collected just above the saturated zone and in intervals where there were elevated photo ionization detector (PID) detections (WCHMHTA001 and WCHMHTA008) (CH2M Hill, 2000). In addition, two confirmatory soil borings were drilled in areas of potential TCE release and sampled in 5-foot intervals for volatile organic compound (VOC) content. Three soil samples were collected for analysis from each of these confirmatory soil borings (totaling 6 samples). These samples were intended to check for the presence of possible unsaturated zone soil contamination in the vicinities of SWMU-3 and SWMU-11 (CH2M Hill, 2000).

Soil analytical results from samples collected during the soil boring and monitoring well installation activities conducted in 1997 are presented in Table 2.2. Soil TCE results were below detection limits for all samples collected by CH2M Hill in 1997. Concentrations of TCE degradation products cis-1,2-DCE, trans-1,2-DCE, and VC, were also below detection limits in all soil samples.

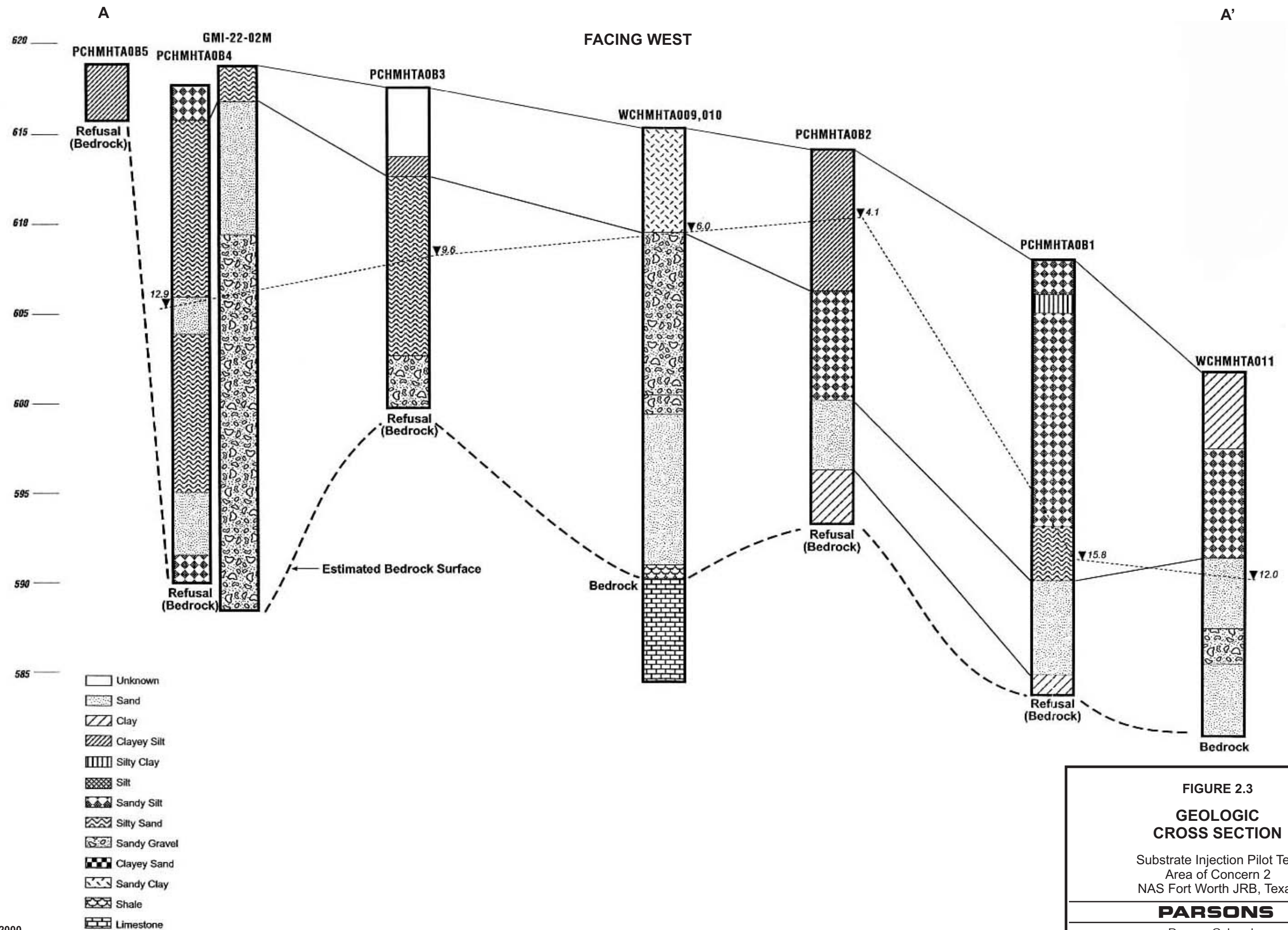


FIGURE 2.3
GEOLOGIC
CROSS SECTION

Substrate Injection Pilot Test
Area of Concern 2
NAS Fort Worth JRB, Texas

PARSONS

Denver, Colorado

TABLE 2.2
VOC DETECTIONS IN SOIL FROM SELECT BORINGS
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Sample Location	Sample Date	Sample Depth (feet bgs) ^{a/}	PCE ^{b/} (mg/kg) ^{c/}	TCE ^{b/} (mg/kg)	cis-1,2-DCE ^{b/} (mg/kg)	trans-1,2-DCE (mg/kg)	1,1-DCE (mg/kg)	Vinyl Chloride (mg/kg)
WCHMHTA007	Nov-97	12 - 14	0.0079 U	0.011 UJ	0.0068 U	0.0034 U	0.0068 U	0.01 UJ
WCHMHTA008	Nov-97	12 - 14	0.0083 U	0.012 UJ	0.0071 U	0.0035 U	0.0071 U	0.011 UJ
	Nov-97	14 - 16	0.041 U	0.059 UJ	0.035 U	0.018 U	0.035 U	0.053 UJ
WCHMHTA009	Nov-97	6 - 8	0.0079 U	0.011 UJ	0.0068 U	0.0034 U	0.0068 U	0.01 UJ
WCHMHTA0011	Nov-97	12 - 14	0.008 U	0.011 UJ	0.0068 U	0.0034 U	0.0068 U	0.01 UJ
WCHMHTA0012	Nov-97	12 - 14	0.04 U	0.057 UJ	0.034 U	0.017 U	0.034 U	0.052 UJ

^{a/} feet bgs = feet below ground surface.

^{b/} PCE = tetrachloroethene, TCE = trichloroethene, and DCE = dichloroethene.

^{c/} mg/kg = milligrams per kilogram.

Additional detected compounds include 1,2,4-trimethylbenzene; 1,2,5-trimethylbenzene; ethylbenzene; m,p-xylene; n-propylbenzene; and sec-, tert-, and n-butylbenzene (CH2M Hill, 2000). These compounds were all detected in samples collected from WCHMHTA008.

2.3.2 Historic Fuel Hydrocarbons in Groundwater

Historically, fuel hydrocarbons have been measured in various wells throughout the North Lobe site at relatively low concentrations. Within the pilot test area, three wells; GMI-22-04M, WCHMHTA010, and WCHMHTA011 have been consistently sampled. Fuel hydrocarbons were analyzed for at each of these wells during various sampling events from 1997 through 1999 and no fuel hydrocarbons were detected above method detection limits.

2.3.3 Dissolved Chlorinated Ethenes in Groundwater

VOCs detected in groundwater at the North Lobe include chlorinated solvents and their daughter products; benzene, toluene, ethylbenzene, and xylenes (BTEX); and other fuel related compounds including naphthalene, butylbenzene, and isopropyltoluene (HydroGeoLogic, 2000). Chlorinated solvents commonly found within the North Lobe include PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE, and VC (HydroGeoLogic, 2000).

A likely source area for VOC contamination in groundwater at NAS Fort Worth JRB is AFP 4, located to the west of the base (HydroGeoLogic, 2000). At AFP 4, past spills of TCE have been reported in the Chemical Process Facility (Building 181) (HydroGeoLogic, 2000). It is believed that TCE has been migrating down a paleochannel toward NAS Fort Worth JRB to the site boundary. From the site boundary, the plume appears to be spreading east along a second paleochannel on NAS Fort Worth JRB property (HydroGeoLogic, 2000). Figure 2.2 shows the general extent of the North Lobe during the October 2002 sampling round.

Groundwater samples have been collected at various times from nine monitoring wells and five temporary direct push groundwater sampling points in the immediate vicinity of the pilot test area. These wells and temporary sampling points are depicted on Figure 2.2 and the available contaminant analytical data for each location is summarized in Table 2.3.

Detected contaminants in groundwater, within the pilot test area, primarily consist of TCE, *cis*-1,2-DCE, and *trans*-1,2-DCE. PCE, 1,1-DCE, VC, benzene, toluene, ethylbenzene, and chloroform have also been detected sporadically and at relatively low concentrations. The chlorinated ethene parent compound TCE is the most common compound detected in this area of the North Lobe plume. TCE has been detected at 11 of the 14 sampling locations at a maximum concentration of 2,318 µg/L at temporary sampling point AGA-24 in 1996. TCE concentrations have been relatively stable through time at locations where multiple sampling events have been conducted. Relatively high concentrations of TCE (>1,000 µg/L) have historically been detected at one monitoring well (WCHMHTA010) and temporary sampling location (PCHMHTA0B1) (Table 2.3). The TCE degradation daughter product *cis*-1,2-DCE has also been detected at relatively high concentrations (>50 µg/L) at two groundwater monitoring wells (GMI-22-04M and

TABLE 2.3
SUMMARY OF SELECT HISTORIC GROUNDWATER VOC ANALYTICAL DATA
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Sample Location	Sample Date	PCE ^{a/} (µg/L) ^{b/}	TCE ^{a/} (µg/L)	1,1-DCE ^{a/} (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2- DCE (µg/L)	VC ^{a/} (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	M,P-Xylenes (µg/L)	Chloroform (µg/L)
MONITORING WELLS												
MW-57	Dec-97	1.4 U ^{c/}	3.8 J	1.2 U	14 J	0.5 J ^{d/}	1.1 U	NA ^{e/}	NA	NA	NA	NA
	Feb-98	1.4 U	1 U	1.2 U	5	0.6 U	1.1 J	NA	NA	NA	NA	NA
GMI-22-02M	Dec-97	1.4 U	1 U	1.2 J	1.2 U	0.6 U	1.1 J	NA	NA	NA	NA	NA
	Feb-98	1.4 U	1 U	1.2 U	1.2 U	0.6 U	1.1 J	NA	NA	NA	NA	NA
	Oct-00	NA	1 U	NA	1 U	1 U	1 U	NA	NA	NA	NA	NA
	Oct-02	1 U	1 U	1 U	1 U	1 U	1 U	0.4 U	1 U	1 U	1 U	0.3 U
GMI-22-04M	Dec-97	28 U	520	24 U	56	11 J	22 J	ND ^{f/}	ND	ND	ND	ND
	Feb-98	28 J	450	24 J	53	8.8 J	22 J	ND	ND	ND	ND	ND
	Apr-98	28 U	520	24 U	59	9.4 J	22 U	ND	ND	ND	ND	ND
	Oct-99	1.0	490	0.5 U	83	6.0	0.5 U	0.4 U	0.5 U	0.5 U	0.5 U	0.5
	Jan-99	0.9	420	ND	80	7.0	ND	ND	ND	ND	ND	0.4
	Apr-99	1.0	520 J	ND	90 J	7.0	ND	ND	ND	ND	ND	0.4
	Jul-99	1 J	380	ND	72	ND	ND	ND	ND	ND	ND	ND
	Oct-99	1.0	490	ND	83	6.0	ND	ND	ND	ND	ND	0.5
WCHMHTA007	Dec-97	35 U	660 J	30 U	9.5 J	15 U	28 J	NA	NA	NA	NA	NA
	Feb-98	28 U	550	12 U	11 J	12 U	22 J	NA	NA	NA	NA	NA
WCHMHTA008	Dec-97	14 U	59 J	12 U	12 U	6 U	11 U	NA	NA	NA	NA	NA
	Feb-98	7 U	22	6 U	6 U	3 U	5.5 U	NA	NA	NA	NA	NA
	Apr-98	7 U	22	6 U	6 U	3 U	5.5 U	NA	NA	NA	NA	NA
	Jun-99	NA	NA	NA	NA	NA	NA	39	NA	34	NA	NA
	Apr-01	0.5 U	8.0	0.5 U	0.5 U	0.5 U	0.5 U	87	0.5 U	160	1 U	0.3 U
	Oct-02	1 U	1.0	1 U	1 U	1 U	1 U	110	1 U	280	2 U	0.3 U
WCHMHTA009	Dec-97	28 U	480	24 U	7.4 J	12 U	22 J	NA	NA	NA	NA	NA
	Feb-98	2.2 J	320	1.2 J	7.9	0.6 J	1.1 J	NA	NA	NA	NA	NA
	Jun-99	2.0	330	ND	6.0	ND	ND	NA	NA	NA	NA	NA
	Oct-00	4.0	350	0.3 J	8.0	0.5 U	0.5 U	0.4 U	0.5 U	0.5 U	0.5 U	0.4
	Apr-01	2.0	200	0.5 U	3.0	0.5 U	0.5 U	0.4 U	0.5 U	0.5 U	0.5 U	0.3 U
WCHMHTA010	Dec-97	70 U	1100 J	60 J	60 U	30 U	55 J	ND	ND	ND	ND	ND
	Feb-98	28 J	330	24 J	24 U	12 J	22 J	ND	ND	ND	ND	ND
	Apr-98	70 U	1100	60 J	60 U	30 U	55 U	ND	ND	ND	ND	ND
	Sep-01	3.9	520	0.33	7.3	0.25	1.5 U	0.8 U	0.26	0.2 U	0.2 U	0.2
	Oct-02	6.1	480	0.51 J	7.9	1 U	1 U	0.4 U	1 U	1 U	1 U	0.71
WCHMHTA011	Dec-97	70 U	420 J	60 J	60 U	30 U	55 J	ND	ND	ND	ND	ND
	Feb-98	70 U	1,200	60 J	28 J	30 U	55 J	ND	ND	ND	ND	ND
	Apr-98	28 U	360	24 U	6.2 J	12 J	22 U	ND	ND	ND	ND	ND
	Sep-01	5.2	223	0.41	5.2	0.26	0.07 U	0.04 U	0.2	0.9 U	0.09 U	0.5
WCHMHTA012	Dec-97	35 U	620 J	30 J	250 J	69 J	28 J	NA	NA	NA	NA	NA
	Feb-98	28 U	410	24 U	160	28	22 J	NA	NA	NA	NA	NA
	Apr-98	1.2 J	580	1.4	180	34 J	13 J	NA	NA	NA	NA	NA
	Oct-00	NA	NA	NA	NA	NA	3.0	0.4 J	NA	NA	NA	NA
DIRECT PUSH POINTS												
PCHMHTA0B1	Nov-97	10	1,800	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCHMHTA0B2	Nov-97	5 U	860	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCHMHTA0B3	Nov-97	5 U	570	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCHMHTA0B4	Nov-97	5 U	5 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
AGA-24	Nov-96	NA	2,318	NA	NA	NA	NA	NA	31	NA	NA	NA
BHGLTA097	Jan-03	0.2 U	26	0.19 U	0.65 J	0.21 U	0.18 U	0.2 U	0.21 U	0.66 J	2.2	0.23 U
BHGLTA098	Jan-03	1.9	130	0.19 U	2.4	0.21 U	0.18 U	0.2 U	0.21 U	0.2 U	0.39 U	0.23 U
BHGLTA099	Jan-03	0.72 J	94	0.19 U	3.2	0.21 U	0.18 U	0.2 U	0.21 U	0.2 U	0.39 U	0.23 U

^{a/} PCE = tetrachloroethene, TCE = trichloroethene, DCE = dichloroethene, VC = vinyl chloride.

^{b/} µg/L = micrograms per liter.

^{c/} U = The analyte was not detected above the associated method detection limit.

^{d/} J = The analyte was positively identified at a concentration above the method detection limit but below the reporting limit. The reported concentration is an estimate.

^{e/} NA = Not available or not analyzed

^{f/} ND = This analyte was not detected above the method detection limit.

WCHMTHA012), with a maximum concentration of 180 µg/L detected at WCHMTHA012. The *cis*-1,2-DCE degradation daughter product VC has been detected sporadically and at low concentrations (below the method reporting limit [RL]) at four locations (Table 2.3).

The presence of relatively high concentrations of the TCE degradation daughter product *cis*-1,2-DCE, and the coincidence of the spatial distribution of high detected concentrations of TCE and *cis*-1,2-DCE, indicate that limited reductive dechlorination of TCE to *cis*-1,2-DCE may be occurring, or may have occurred, at this site. However, the lack of significant concentrations of VC indicate that any reductive dechlorination that may be occurring is relatively limited in extent and may not be proceeding beyond *cis*-1,2-DCE.

An in depth discussion of the North Lobe nature and extent of contamination can be found in Section 5 of HydroGeoLogic, 2000.

2.4 Historic Groundwater Geochemistry

Since 1995, natural attenuation parameters have been collected at the North Lobe on a regular basis (semi-annual prior to July 1997 and quarterly since July 1997) at 11 select wells. Of the 11 wells sampled regularly, one well (GMI-22-04M) is within close proximity to the pilot test area. Monitored natural attenuation (MNA) parameters sampled for include common anions (EPA Method 9060), methane, ethane, ethane (Method RSK-175), and alkalinity (EPA Method 310.1), as well as several of the standard field parameters collected at every well (pH, temperature, conductivity, ORP, and dissolved oxygen [DO]). During this same time period, CH2MHILL also conducted a RCRA Facility Investigation (RFI) at the North Lobe (CH2MHill, 1998). Data evaluations from both the RFI and the quarterly natural attenuation data have virtually the same conclusion; while some reductive dechlorination has occurred within the TCE plume, it is limited in extent. Historic geochemical data for GMI-22-04M, and for six other wells that have been sampled sporadically for MNA parameters, is presented in Table 2.4.

2.4.1 Electron Donors

2.4.1.1 Total Organic Carbon

Total organic carbon (TOC) can be used as a measure of substrate that can provide electron donor during the reductive dechlorination of chlorinated solvents. TOC concentrations can be used as an indicator of the presence of such native carbon compounds in wells outside of the area containing dissolved contamination (anthropogenic organic compounds, such as CAHs, petroleum hydrocarbons, or landfill leachate also are measured by the TOC analytical method). TOC concentrations in excess of 20 milligrams per liter (mg/L) are desirable to drive reductive dechlorination reactions (USEPA, 1998).

Throughout the North Lobe site, TOC concentrations are extremely low, averaging less than 4 mg/L over the 62 wells sampled between January 1998 and October 1999 (HydroGeoLogic, 2000). The wells with the lowest TOC concentrations correlate to areas of highest TCE concentrations (HydroGeoLogic, 2000).

TABLE 2.4
SUMMARY OF HISTORIC GROUNDWATER GEOCHEMICAL DATA COLLECTED IN THE VACINITY OF THE PILOT TEST AREA
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Sample Location	Sample Date	Temp. (°C) ^{a/}	pH (SU) ^{b/}	Dissolved Oxygen (mg/L) ^{c/}	Redox Potential (mV) ^{d/}	Specific Conductivity µs/cm ^{e/}	Total Alkalinity (mg/L)	Chloride (mg/L)	Ferrous Iron (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	TOC (mg/L)	Methane (mg/L)	Ethane (µg/L) ^{f/}	Ethene (µg/L)
GMI-22-02M	Dec-97	20.8	7.1	2.1	141	355	NA ^{g/}	NA	0.01	NA	NA	NA	NA	NA	NA
	Apr-98	22.1	6.8	0.6	34	459	NA	NA	0.09	NA	NA	NA	NA	NA	NA
	Oct-99	21.2	6.4	NA	NA	704	NA	NA	NA	NA	NA	NA	NA	NA	NA
	May-00	19.7	6.3	4.5	142	519	NA	NA	NA	NA	NA	NA	NA	NA	NA
	May-01	19.5	7.1	3.6	NA	496	NA	NA	NA	NA	NA	NA	NA	NA	NA
GMI-22-04M	Jan-98	NA	NA	NA	NA	NA	NA	NA	NA	0.09	51	ND	NA	2.3	ND
	Apr-98	NA	NA	NA	NA	NA	NA	NA	NA	NA	43	1.4	NA	1.2	ND
	Jul-98	NA	NA	NA	NA	NA	NA	NA	NA	NA	47	1.2	NA	3.2	ND
	Oct-98	NA	NA	NA	NA	NA	NA	NA	NA	NA	49	1.4	NA	ND	ND
	Jan-99	23.5	6.8	2.1	78	NA	380	89	ND	7.5	42	1.8	3.0	1.3	ND
	Apr-99	22.3	7.1	1.3	52	NA	383	92	ND	9.5	45	1.6	6.0	NA	NA
	Jul-99	24.0	7.3	2.9	-5.1	NA	410	75	ND	7.4 J	34 J	2.5	4.0	2.0	ND
WCHMHTA008	Oct-99	24.8	6.9	NA	82	1,157	364	81	ND	6.9	43	1.6	4.6	1.9	1.9
	Sep-98	NA	NA	NA	NA	NA	441	357	NA	1.8	44.6	NA	2.3	25 U	25 U
WCHMHTA009	Oct-99	24.3	6.5	16.5	-118	2,226	464	373	1.45	2.3	46 ^{h/}	3.3	3.2	1 U	1 U
WCHMHTA010	Oct-99	30.4	6.8	7.0	129	1,135	284	80.5	0.29	8.3	42	2.3	3.9	1 U	1 U
WCHMHTA011	Sep-98	NA	NA	NA	NA	NA	343	105	NA	18	3.8	NA	5 U	5 U	5 U
	Sep-01	NA	NA	NA	NA	NA	316	133	NA	13.6	52.9	2.31	0.19	0.07 U	0.07 U
WCHMHTA012	Sep-98	NA	NA	NA	NA	NA	303	121	NA	9.5	47.4	NA	0.2	5 U	5 U
	Sep-01	NA	NA	NA	NA	NA	334	125	NA	8.9	50.8	3.1	3.5	0.08 U	0.08 U
WCHMHTA012	Dec-97	28.1	6.8	0.4	-59	1,420	NA	NA	2.4	NA	NA	NA	NA	NA	NA

^{a/} °C = degrees Celcius.

^{b/} SU = standard units.

^{c/} mg/L = milligrams per liter

^{d/} mV = millivolts.

^{e/} µs/cm = microsiemens per centimeter

^{f/} µg/L = micrograms per liter

^{g/} NA = Not Available or not analyzed.

^{h/} This data was collected in July, 1999.

TOC concentrations measured historically in the vicinity of the pilot test area ranged from non-detect to 3.3 mg/L (Table 2.4). Native organic carbon concentrations of this magnitude are insufficient to drive reductive dechlorination of CAHs.

2.4.2 Alternate Electron Acceptors and Metabolic Byproducts

Biodegradation of organic compounds, whether natural or anthropogenic, brings about measurable changes in the chemistry of groundwater in the affected area. Concentrations of compounds used as electron acceptors (e.g., DO, nitrate, and sulfate) are depleted, and byproducts of electron acceptor reduction (e.g., ferrous iron, methane, ethene, ethane, and sulfide) are elevated. By measuring these changes, it is possible to evaluate what biological processes are occurring at a particular site. Results of alternate electron acceptor and metabolic byproduct analyses for the North Lobe are presented in Table 2.4. The following paragraphs discuss those parameters most useful in evaluating biodegradation processes.

2.4.2.1 Dissolved Oxygen

During the four quarterly sampling events of 1999 (January, April, July, and October), DO levels ranged from 0 to 14 mg/L throughout the North Lobe (HydroGeoLogic, 2000). DO concentrations measured historically in the vicinity of the pilot test area ranged from 0.4 to 16.5 mg/L (Table 2.4). DO concentrations less than 0.5 mg/L are indicative of reducing geochemical conditions are necessary for the onset of anaerobic biodegradation (USEPA, 1998).

The extreme heterogeneity of DO concentrations measured in the vicinity of the pilot test area indicate that microbial processes are consuming DO and creating anaerobic conditions in some areas but not in others. The discontinuous nature of microbial activity is likely do to the presence of localized pockets of material that are acting as carbon sources. These carbon source materials could consist of native anthropogenic carbon in the soil matrix, localized areas with fuel related compounds present, or localized areas where fill material contains a high proportion of organic material such as wood construction debris or plant material.

2.4.2.2 Nitrate (as Nitrogen)

After DO has been depleted in the microbiological treatment zone, nitrate may be used as an electron acceptor for anaerobic biodegradation of organic carbon via denitrification. Nitrate concentrations below background in areas with high organic carbon concentrations and low DO are indicative of denitrification. The oxidation of organic carbon via the process of denitrification (using nitrate as an electron acceptor) yields a relatively large amount of free energy to microbial populations and can occur at the expense of reductive dechlorination in areas with high nitrate concentrations. In order for reductive dechlorination to occur, nitrate concentrations in the contaminated portion of the aquifer must be below 1 mg/L (USEPA, 1998).

Concentrations of nitrate [as nitrogen (N)] were measured in groundwater samples collected quarterly in 1999. Throughout the North Lobe, nitrate concentrations ranged from non-detect to 51 mg/L during 1999 (HydroGeoLogic, 2000). The maximum concentration of nitrate throughout the North Lobe decreased with each successive

sampling event (51 mg/L in January, 22 mg/L in April, 7.4 mg/L in July, and 6.9 mg/L in October) (HydroGeoLogic, 2000). Nitrate concentrations measured at GMI-22-04M January 1998 through October 1999 ranged from 0.9 mg/L to 9.5 mg/L (Table 2.4). Nitrate concentrations in close proximity to the pilot test area are all relatively low (<20 mg/L) and do not vary significantly through time (GMI-22-04M). The mechanisms responsible for the observed decreases in nitrate concentration are unknown as very little geochemical data has been collected during past sampling events. These observed nitrate concentrations indicate that nitrate reduction should not be a significant competing biodegradation process to reductive dechlorination.

2.4.2.3 Ferrous Iron

The reduction of ferric iron [iron (III)] has been shown to be a major metabolic pathway for some microorganisms (Lovley and Phillips, 1988; Chapelle, 1993). The reduction of ferric iron results in the formation of ferrous iron [iron (II)], and elevated concentrations of iron (II) often are found in anaerobic groundwater systems. Ferrous iron concentrations once were attributed to the abiotic spontaneous and reversible reduction of ferric oxyhydroxides, which are thermodynamically unstable in the presence of organic compounds such as BTEX, trimethylbenzenes (TMBs), and naphthalene. However, recent evidence suggests that the reduction of ferric iron cannot proceed at all without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993). Ferrous iron concentrations above background levels in contaminated areas is an indication that iron reduction is occurring at the expense of reductive dechlorination.

Concentrations of ferrous iron were measured in groundwater samples collected quarterly in 1999. Throughout the North Lobe, ferrous iron concentrations ranged from non-detect to 7.05 mg/L during 1999 (HydroGeoLogic, 2000). Ferrous iron concentrations measured in the vicinity of the pilot test area ranged from below the MDL to a maximum of 2.4 mg/L. The relatively low concentrations coupled with lack of temporal variability in iron (II) concentrations (GMI-22-04M) indicate that significant iron (III) reduction is not occurring at this site.

2.4.2.4 Sulfate

Sulfate also may be used as an electron acceptor during microbial degradation of natural or anthropogenic organic carbon under anaerobic conditions (Grbic-Galic, 1990). This redox reaction is commonly called sulfate reduction. Sulfate concentrations greater than 20 mg/L competitive exclusion of reductive dechlorination, although significant reductive dechlorination has been observed at many sites where sulfate concentrations range as high as 100 mg/L (USEPA, 1998).

Concentrations of sulfate were measured in groundwater samples collected quarterly in 1999. Throughout the North Lobe, sulfate concentrations ranged from non-detect to 377 mg/L during 1999 (HydroGeoLogic, 2000). Sulfate concentrations measured at GMI-22-04M from January 1998 to October 1999 ranged from 34 mg/L to 51 mg/L. The concentrations within the pilot test area are not depleted compared to the range of concentrations throughout the area, indicating that it is unlikely that sulfate reduction is an ongoing anaerobic degradation process. In addition, these levels of sulfate should not

pose a significant competing biodegradation process to reductive dechlorination at this site.

2.4.2.5 Methane, Ethane, and Ethene

Although anaerobic degradation may occur under nitrate- iron-, and sulfate-reducing conditions (Vogel *et al.*, 1987; Chapelle, 1996), the most rapid biodegradation rates occur under methanogenic conditions (Bouwer, 1994). Elevated concentrations of methane, ethene, and ethane above background concentrations are indications of methanogenesis and potentially reductive dechlorination. Concentrations of methane, ethane, and ethene were measured in groundwater samples collected quarterly in 1999. Throughout the North Lobe in 1999, methane concentrations ranged from non-detect to 6 mg/L, ethane and ethane concentrations combined ranged from non-detect to 3.2 µg/L (HydroGeoLogic, 2000). Methane concentrations measured at GMI-22-04M, January 1998 through October 1999 ranged from 3 mg/L to 6 mg/L, ethane concentrations ranged from non-detect to 3.2 mg/L and ethane concentrations ranged from non-detect to 1.9 mg/L. In 2001 methane concentrations were measured at WCHMHTA010 (0.19 mg/L) and at WCHMHTA011 (3.5 mg/L). The low methane concentrations detected in the pilot test area with respect to background areas, indicate that it is unlikely that methanogenesis is an ongoing anaerobic degradation process in this area. The low concentrations of ethane and ethene indicate that these compounds are not being produced in significant quantities in this area.

2.4.3 Oxidation Reduction Potential as an Indicator of Redox Processes

ORP is a measure of the relative tendency of a solution to accept or transfer electrons. The ORP of a groundwater system depends on which electron acceptors are being reduced by microbes during oxidation of organic compounds. For example, by coupling the oxidation of fuel hydrocarbon compounds (or native organic carbon), which requires energy, to the reduction of other compounds (e.g., oxygen, nitrate, manganese, ferric iron, sulfate, carbon dioxide, and possibly *cis*-1,2-DCE), which yields energy, the overall reaction will yield energy.

In general, reactions yielding more energy tend to take precedence over processes that yield less energy (Stumm and Morgan, 1981; Godsey, 1994). Oxygen reduction would be expected in an aerobic environment with microorganisms capable of aerobic respiration, because oxygen reduction yields significant energy (Bouwer, 1992; Chapelle, 1993). However, once the available DO is depleted and anaerobic conditions dominate the interior regions of a contaminant plume, anaerobic microorganisms can utilize other electron acceptors in the following order of preference: nitrate (denitrification), manganese (manganese reduction), ferric iron (iron reduction), sulfate (sulfate reduction), and finally carbon dioxide (methanogenesis). Each successive redox reaction provides less energy to the system, and each step down in redox energy yield is paralleled by an ecological succession of microorganisms capable of facilitating the pertinent redox reactions.

ORP was measured in groundwater samples collected quarterly in 1999. Throughout the North Lobe, ORP ranged from -180 millivolts (mV) to 287 mV during 1999 (HydroGeoLogic, 2000). ORP measured in the vicinity of the pilot test area ranged from

-118 mV to 142 mV and averaged 48 mV. Within single wells the ORP data appears to vary considerably from one sampling event to the next (e.g., GMI-22-04M). These large swings in ORP indicate that the geochemical environment tends to move drastically between oxidizing and reducing geochemical environments. This supposition is supported by large changes in DO data (Table 2.4). The observed changes are likely a result of changes in groundwater flow conditions resulting from precipitation events. After a large precipitation event the shallow groundwater aquifer is flooded with relatively oxidizing surface water which results in a geochemical swing toward more oxidizing conditions. In times with little rain fall the groundwater geochemistry swings toward a more reducing environment as available DO is consumed by the naturally occurring bacterial population.

The historic ORP data (Table 2.4) indicates that the groundwater chemistry in the vicinity of the pilot test area is generally oxidizing, with some localized areas of reducing conditions. One of the localized reducing zones (WCHMHTA012) corresponds to the lowest DO concentration detected and the highest ratio of cis-1,2-DCE concentration to TCE concentration detected. These observations indicate that limited reductive dechlorination may be occurring in a localized area in the vicinity of this well.

2.4.4 Additional Geochemical Indicators

2.4.4.1 Alkalinity

An increase in alkalinity (measured as calcium carbonate [CaCO_3]) in an area with fuel hydrocarbons or chlorinated solvent (particularly less-chlorinated solvents) concentrations elevated above background conditions can be used to infer that fuel hydrocarbons, less-chlorinated solvents, or native organic carbon has been degraded through aerobic and anaerobic microbial respiration.

Total alkalinity (as CaCO_3) was measured in groundwater samples collected quarterly in 1999. Throughout the North Lobe, alkalinity ranged from 199 mg/L to 513 mg/L during 1999 (HydroGeoLogic, 2000). Alkalinity measured at GMI-22-04M, January 1999 through October 1999 ranged from 364 mg/L to 410 mg/L. Alkalinity is a measure of the ability of groundwater to buffer changes in pH. This relatively high alkalinity level should be sufficient to buffer potential changes in pH caused by biologically mediated reactions which would be stimulated with the addition of organic substrate.

2.5 SUMMARY OF HISTORIC GEOCHEMICAL AND CONTAMINANT CONDITIONS WITHIN THE PILOT TEST AREA

Chlorinated ethenes detected in groundwater at the North Lobe include PCE, TCE, DCE, and VC. While extensive groundwater monitoring has occurred throughout the North Lobe from 1997 to present, limited data is available for the pilot test area. Overall, the spatial extent of the North Lobe plume and concentrations within the North Lobe plume have remained fairly consistent over time (HydroGeoLogic, 2000). Overall, TCE and DCE concentrations have decreased or remained the stable with minor seasonal fluctuations. Historical data indicates that the downgradient extent of the plume has remained relatively stable over the past 5 to 6 years.

Within the pilot test area, three wells; GMI-22-04M, WCHMHTA010, and WCHMHTA011, have been sampled consistently from 1997 to present. Elevated TCE concentrations have been measured at wells WCHMHTA010 and WCHMHTA011 (1,100 µg/L and 1,200 µg/L respectively in 1999). *cis*- and *trans*-1,2-DCE concentrations are relatively low at these well locations, however *cis*- and *trans*-1,2-DCE concentrations are elevated downgradient (at well GMI-22-04M). Historically, PCE has been below reporting limits or at very low concentrations (1.0 µg/L) at all sampled wells. 1,1-DCE and VC were not detected at any wells during any of the sampling events.

Historic groundwater geochemical conditions indicate that while some reductive dechlorination is occurring or has occurred within the North Lobe, it has been limited in extent. However, within the pilot test area, conditions may be conducive to reductive dechlorination as indicated by the low DO levels and low nitrate levels. ORP conditions are easily and readily modified by the injection of an organic substrate (vegetable oil). Therefore, the weakly oxidizing conditions currently present in the pilot test area are not expected to delay or inhibit the onset of anaerobic degradation processes. The absence of significant concentrations of competing electron acceptors (nitrate and sulfate) indicate that after DO and ORP have been depressed (DO <1 mg/L and ORP <-200 mV) reductive dechlorination should proceed at significantly higher rates than those observed historically.

SECTION 3

ENHANCED BIOREMEDIATION OF CHLORINATED SOLVENTS USING VEGETABLE OIL

Chlorinated solvents can be transformed, directly or indirectly, by biological processes (e.g., Bower, 1994; Freedman and Gossett, 1989; DeStefano *et al.*, 1991; Henry, 1991; McCarty *et al.*, 1992; Chapelle, 1993; McCarty and Semprini, 1994; Vogel, 1994; Bradley and Chapelle, 1996; Bradley and Chapelle, 1998). Biodegradation of chlorinated solvents, also termed CAHs, results from the same general processes that bring about biodegradation of fuel hydrocarbons. However, a more complex series of processes often is involved, as CAHs may act either as substrates (electron donors) or electron acceptors depending upon the prevailing geochemical conditions.

Chlorinated solvents may undergo biodegradation through three different pathways: use as an electron acceptor, use as an electron donor, or cometabolism, which is degradation resulting from exposure to a catalytic enzyme fortuitously produced during an unrelated process. At a given site, one or all of these processes may be operating, although at many sites the use of CAHs as electron acceptors appears to be the most likely.

In a pristine aquifer, native organic carbon is utilized as an electron donor and DO is utilized first as the prime electron acceptor. Where anthropogenic carbon (e.g., vegetable oil, fuel hydrocarbons, landfill leachate, or less-chlorinated CAHs), is present, it also may be utilized as an electron donor. Most chlorinated solvents that can act as electron donors have thus far only been demonstrated to do so under aerobic conditions, with the notable exception of VC (Bradley and Chapelle, 1996 and 1998). After the DO is consumed, anaerobic microorganisms typically use native electron acceptors (as available) in the following order of preference: nitrate, manganese, ferric iron oxyhydroxide, sulfate, and finally carbon dioxide. Evaluation of the distribution of these electron acceptors can provide evidence of where and how biodegradation of chlorinated solvents is occurring.

Under anaerobic conditions, biodegradation of chlorinated solvents typically proceeds through a process called reductive dechlorination. During reductive dechlorination, the halogenated hydrocarbon is used as an electron acceptor, not as a source of carbon, and a chloride atom is removed and replaced with a hydrogen atom. Figure 3.1 illustrates the transformation of chlorinated ethenes via reductive dechlorination. In general, reductive dechlorination occurs by sequential dechlorination. For the chlorinated ethenes, dechlorination progresses from PCE to TCE to DCE to VC to ethene.

For the chloroethanes, dechlorination progresses from TCA to DCA to chloroethane to ethane. Likewise, for the chlorinated methanes, dechlorination progresses from CT to

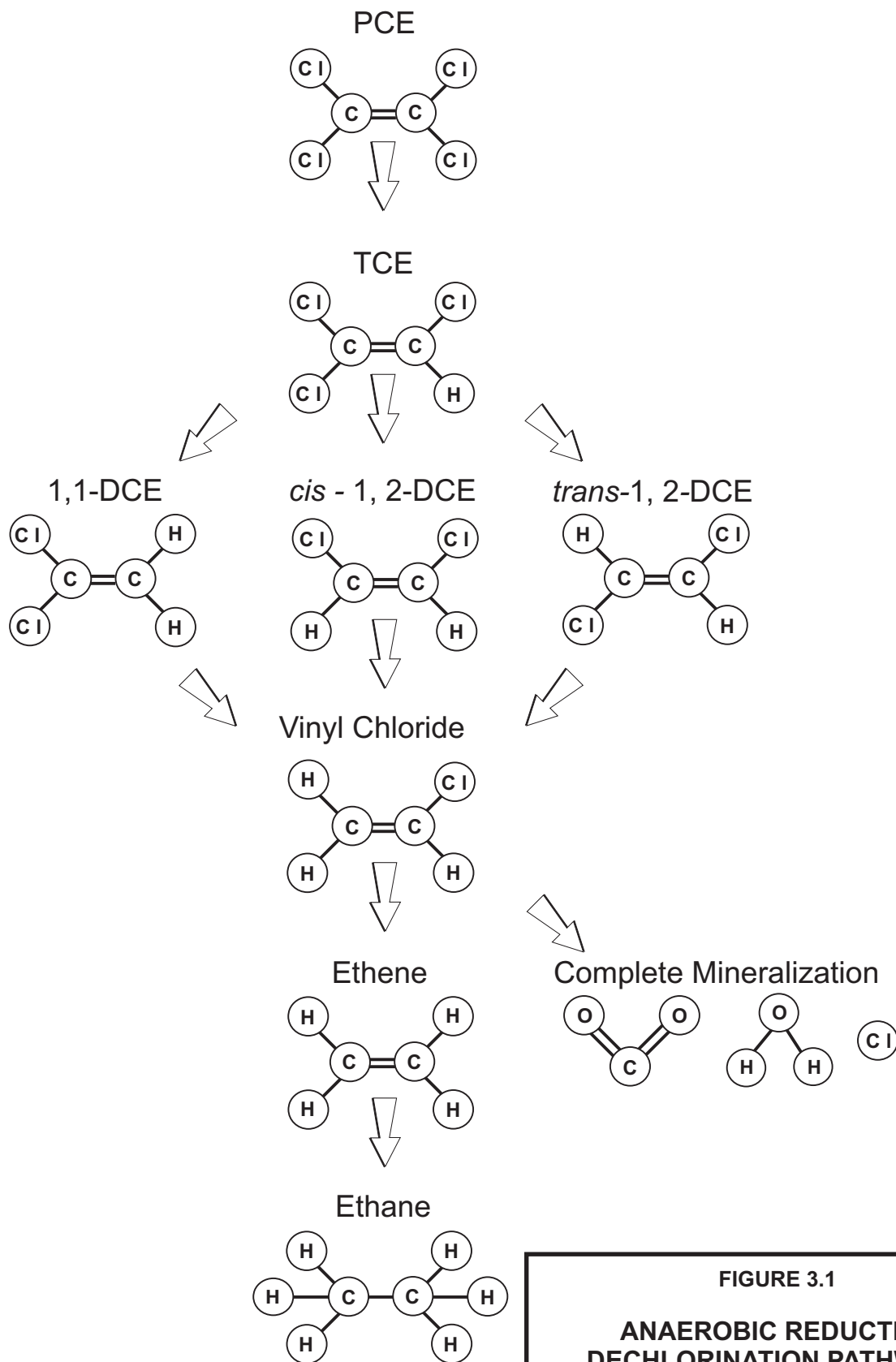


FIGURE 3.1

**ANAEROBIC REDUCTIVE
DECHLORINATION PATHWAYS**

Substrate Injection Pilot Test
Area of Concern 2
NAS Fort Worth JRB, Texas

PARSONS

Denver, Colorado

chloroform to methylene chloride to chloromethane to methane. Depending upon environmental conditions, these dechlorination sequences may be interrupted, with other processes then acting upon the products. During reductive dechlorination of TCE, all three isomers of DCE can theoretically be produced; however, Bouwer (1994) reports that under the influence of biodegradation, *cis*-1,2-DCE is a more common intermediate than *trans*-1,2-DCE, and that 1,1-DCE is the least prevalent intermediate of the three DCE isomers. Reductive dechlorination of chlorinated solvent compounds is associated with the accumulation of daughter products and an increase in chloride.

Reductive dechlorination affects each of the chlorinated solvents differently. PCE, TCE, TCA, and CT are the most susceptible of these compounds to reductive dechlorination because they are the most oxidized. Conversely, VC, chloroethane, and chloromethane are the least susceptible to reductive dechlorination because they are the least oxidized of these compounds. Reductive dechlorination has been demonstrated under nitrate-, iron-, and sulfate-reducing conditions, but the most rapid biodegradation rates, affecting the widest range of CAHs, occur under methanogenic conditions (Bouwer, 1994).

Because CAH compounds are used as electron acceptors, there must be an appropriate source of carbon for microbial growth in order for reductive dechlorination to occur. Potential carbon sources include vegetable oil, fuel hydrocarbons, low-molecular-weight compounds (e.g., lactate, acetate, methanol, or glucose) present in natural organic matter or less-chlorinated compounds such as DCE, VC, chloroethane, or chloromethane (Wiedemeier et al., 1999).

The separate phase nature of vegetable oil allows for slow dissolution into groundwater, making it a slow release carbon source. Thus, the carbon substrate acts as a source of organic carbon and hydrogen for several years, which will significantly reduce overall costs. Vegetable oil is an inexpensive, innocuous, food-grade carbon source. Because vegetable oil is a non-aqueous phase liquid (NAPL), the potential exists that a single, low cost, injection could provide sufficient carbon to drive reductive dechlorination for many years.

Vegetable oil will be injected within the Northern Lobe (in the immediate vicinity of WCHMHTA009 and WCHMHTA009) to create the DO, ORP, and electron donor conditions necessary to promote the reductive dechlorination of the chlorinated ethene mass present in the subsurface in this area. A secondary benefit is partitioning of the dissolved chlorinated solvents into the vegetable oil NAPL (Bielefeldt, 2002). This is beneficial because aqueous-phase chlorinated solvent concentrations are lowered until steady state conditions are reached. This results in an initial attenuation of the dissolved phase plume. Contaminants are then released from the oil to groundwater at a rate dependent upon dissolution and/or degradation of the vegetable oil, and degradation of contaminants in the dissolved phase. In any event, contaminants are released back to groundwater within a zone of adequate substrate and optimal conditions for reductive dechlorination.

SECTION 4

FIELD PROGRAM

4.1 PERFORMANCE OBJECTIVES

The primary performance objectives are to demonstrate that the addition of an organic substrate will enhance rates of degradation of CAHs by an order of magnitude or more. The secondary objectives are to determine design parameters for potential full-scale applications of this technology at NAS Fort Worth JRB. These objectives will be accomplished by installing a series of ten groundwater monitoring wells and injecting vegetable oil and high fructose corn syrup into the subsurface using direct injection techniques. After the substrates have been injected, the groundwater in the pilot test area will be monitored for geochemical changes and contaminant mass reduction over time. The goal of this study is not to remediate the site to below regulatory criteria, but rather to determine whether carbon substrate addition, in the form of vegetable oil, is an effective technology to accelerate *in-situ* CAH mass destruction through biologically mediated reductive dechlorination.

4.2 OVERALL APPROACH

The proposed layout of the field test site in the North Lobe is depicted on Figure 4.1. Proposed site activities include the installation of three soil vapor monitoring wells (VMWs), ten groundwater monitoring wells (GMWs), and eight substrate injection wells (SIWs). The injection wells will be installed in a barrier configuration so that as contaminant mass flows through the barrier with advective groundwater flow it will be reductively dechlorinated. It is expected that only a portion of the contaminant mass will be treated within the injection area and that treatment will continue as the contaminant mass is transported beyond the injection area and through the treatment area. The monitoring wells will be installed within the injection area and at various distances downgradient of the injection area to monitor geochemical and contaminant concentration changes within and downgradient from the injection area. Monitoring wells PES-GMW-01, PES-GMW-02, PES-GMW-03, PES-GMW-04, and PES-GMW-06 will also be used to estimate the radius of influence of the substrate injection.

Immediately prior to vegetable oil injection, a round of baseline sampling and aquifer testing will be conducted in the pilot test area to establish pre-injection conditions. Baseline aquifer testing and sampling and analysis activities are summarized in Table 4.1, and are discussed in further detail in Section 4.4. The groundwater extracted during the well development and baseline sampling tasks will be containerized onsite for later re-injection with the vegetable oil. After the baseline activities are complete, the previously extracted groundwater will be amended with vegetable oil and high fructose

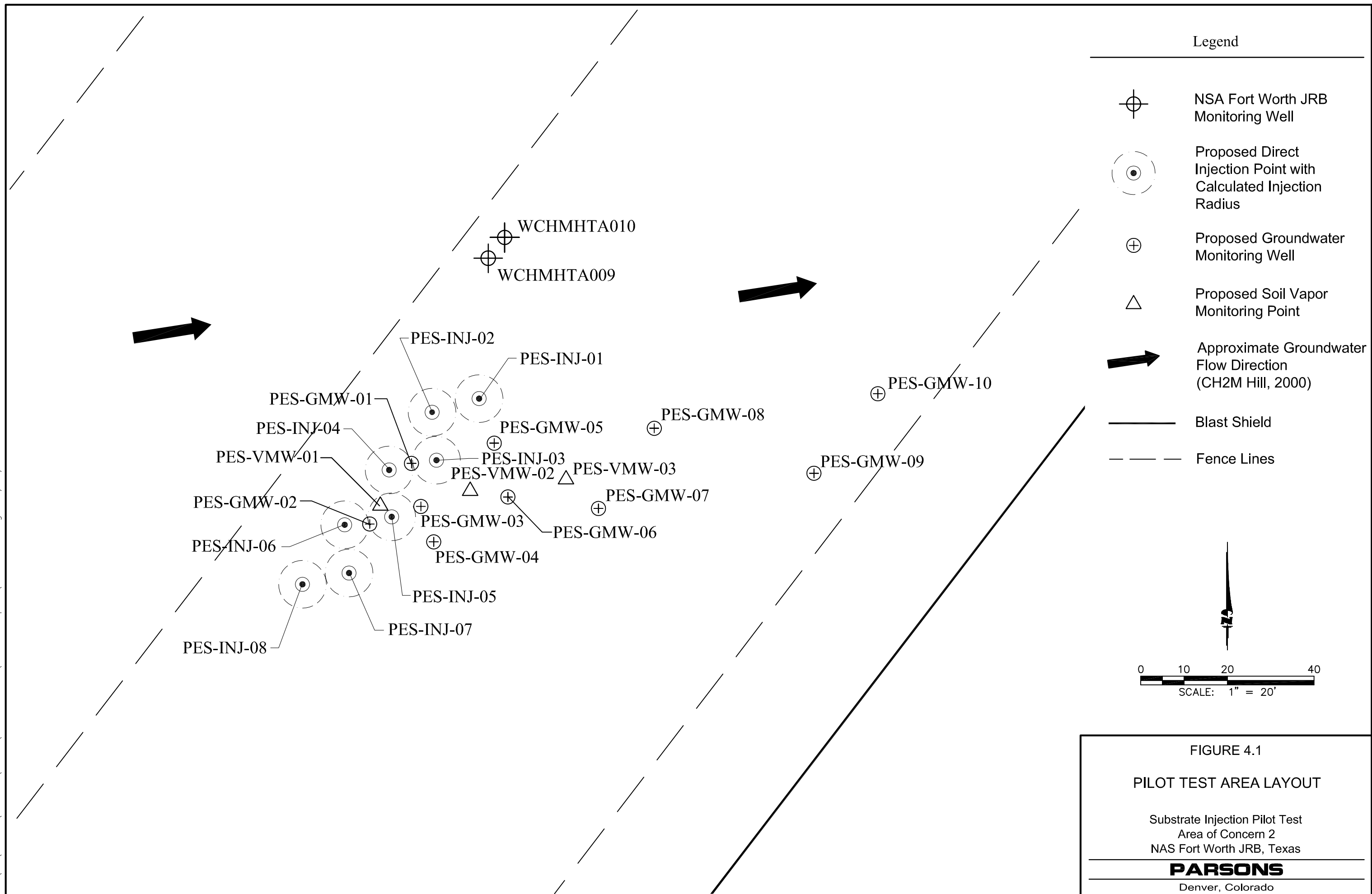


TABLE 4.1
SUMMARY OF PROPOSED BASELINE ACTIVITIES
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Location	Monitoring Well Installation	Approximate Screened Interval (ft bgs) ^{a/}	Aquifer Tests	Water Level Measurement	Soil Vapor Analyses	Soil Analyses		Groundwater Analyses										
					Methane, Oxygen, Carbon Dioxide (Field Meter)	Total Organic Carbon (Walkley Black)	VOCs ^{b/} SW8260B	VOCs ^{b/} SW8260B	Methane, Ethane, Ethene (AM-18/20GAX)	Nitrate (E353.1)	Bromide (E320.1)	Chloride, Sulfate (E300.1)	Total Organic Carbon (SW9060)	Dissolved Metals ^{c/} (SW6010)	Volatile Fatty Acids	Phospholipid Fatty Acids	Well Head Analyses ^{d/}	Mobile Lab Analysis ^{e/}
Soil Gas Monitoring Points																		
PES-VMP-01	1	4 - 6			1													
PES-VMP-02	1	4 - 6			1													
PES-VMP-03	1	4 - 6			1													
Groundwater Monitoring Points																		
PES-GMW-01	1	10 - 25	1	1		1	1	1	1	1	1	1	1		1	1	1	1
PES-GMW-02	1	10 - 25	1	1				1	1	1		1	1	1			1	1
PES-GMW-03	1	10 - 25	1	1		1	1	1	1	1		1	1		1		1	1
PES-GMW-04	1	10 - 25		1				1	1	1		1	1		1	1	1	1
PES-GMW-05	1	10 - 25		1				1	1	1		1	1				1	1
PES-GMW-06	1	10 - 25	1	1		1	1	1	1	1		1	1		1	1	1	1
PES-GMW-07	1	10 - 25	1	1		1	1	1	1	1		1	1	1	1	1	1	1
PES-GMW-08	1	10 - 25		1				1	1	1		1	1				1	1
PES-GMW-09	1	10 - 25		1				1	1	1		1	1		1		1	1
PES-GMW-10	1	10 - 25		1				1	1	1		1	1				1	1
Existing Monitoring Wells																		
WCHMHTA009		4.5 - 12		1	1			1	1	1		1	1	1			1	1
WCHMHTA010		15 - 25		1				1	1	1	1	1	1		1	1	1	1
Injection Locations																		
SUBTOTALS	13		5	12	4	4	4	12	12	12	2	12	12	3	7	5	12	12
QA/QC																		
Duplicates								1	1	1		1	1					1
Matrix Spike								1										
Matrix Spike Duplicate								1										
Trip Blanks								2										
TASK TOTAL:					4	4	4	17	13	13	2	13	13	3	7	5	12	13

^{a/} ft bgs = feet below ground surface.
^{b/} VOCs to include aromatic and chlorinated aliphatic hydrocarbons.
^{c/} Dissolved metals analysis will include arsenic, manganese, and selenium.
^{d/} Well head analyses include dissolved oxygen, oxidation-reduction potential, pH, temperature, and electrical conductivity.
^{e/} Mobile lab analyses include carbon dioxide, chloride, alkalinity, sulfide, ferrous iron, and manganese.

corn syrup to form a fine micro-emulsion. The substrate emulsion will then be injected directly into the subsurface through steel Geoprobe[®] rods at eight injection points. The emulsification and injection steps will be run simultaneously. Immediately after the substrate is injected hydraulic conductivity testing will be performed to quantify short-term impacts to the hydraulic conductivity of the aquifer matrix caused by the substrate injection activities. At approximately six months and one year after injection, groundwater sampling events will be conducted to quantify changes in groundwater geochemistry and contaminant concentrations.

Direct push drilling equipment will be used to install a total of three VMWs, ten GMWs, and eight temporary SIWs. The proposed wells that will be installed are depicted on Figure 4.1. All wells installed for the pilot test will be constructed in a similar manner as shown on Figure 4.2. Prior to the commencement of any drilling activities, both NAS Fort Worth JRB and utility company work clearances will be obtained by Parsons or NAS Fort Worth JRB personnel.

Baseline contaminant concentrations and geochemical parameters will be measured at two existing monitoring wells (WCHMHTA009 and WCHMHTA010) and in ten new GMWs installed within, and downgradient of, the vegetable oil injection area. Methane, carbon dioxide, and oxygen content in soil vapor will be measured in the three newly installed VMWs using a field instrument.

After the baseline sampling event is completed, a small volume of native groundwater amended with high fructose corn syrup will be injected into the subsurface via eight injection wells. This pre-vegetable oil injection of fructose amended groundwater is designed as a fast degrading carbon source that will rapidly establish anaerobic conditions within the aquifer. After the initial injection is complete a vegetable oil-in-water emulsion will be injected into the same area within the eight injection wells. The vegetable oil emulsion injection will serve to distribute a relatively large volume of vegetable oil (approximately 400 gallons) in the subsurface as a dilute vegetable oil/water mixture. The vegetable oil-in-water emulsion will then be followed by a fructose-amended “water push” to force the vegetable oil out into the aquifer matrix and thereby improve the distribution of vegetable oil in the subsurface. The vegetable oil is designed to act as a slowly soluble and long-term substrate that will serve as a source for organic carbon and hydrogen after the fructose has been depleted. After substrate injection activities are complete a round of groundwater elevation measurements will be collected to document the impact to the water table by the substrate injection activities.

At approximately six and 12 months following substrate injection, process monitoring sampling events will be conducted to evaluate the progress of the pilot test. Each process monitoring event will consist of contaminant concentrations and geochemical parameter measurements at two existing monitoring wells (WCHMHTA009 and WCHMHTA010) and in ten new GMWs installed within, and downgradient of, the vegetable oil injection area. Methane, carbon dioxide, and oxygen content in soil vapor also will be measured in the three newly installed VMWs using a field instrument.

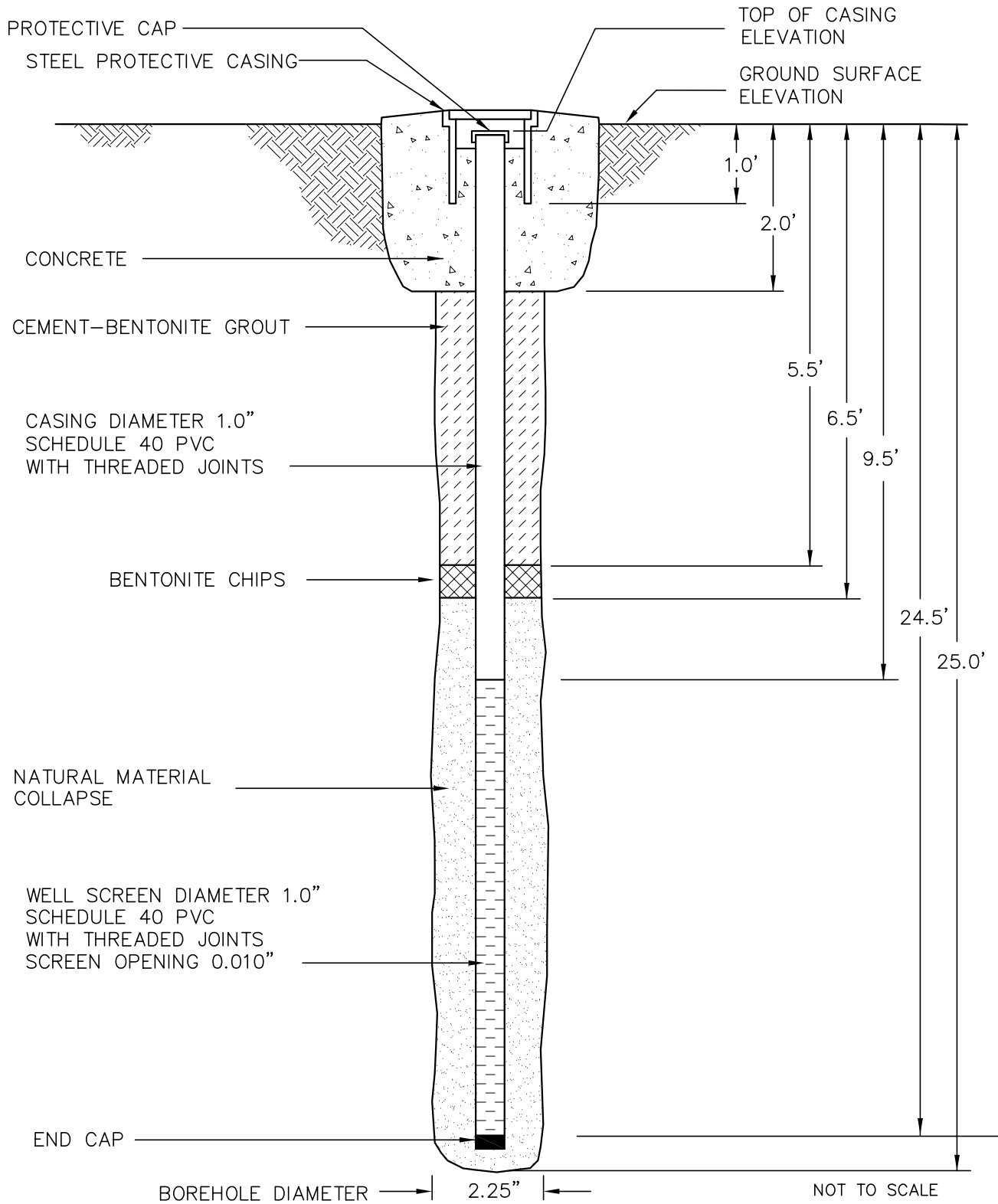


FIGURE 4.2
TYPICAL WELL POINT
CONSTRUCTION DIAGRAM

Substrate Injection Pilot Test
Area of Concern 2
NAS Fort Worth JRB, Texas

PARSONS

Denver, Colorado

4.3 DRILLING AND SOIL SAMPLING ACTIVITIES

4.3.1 Vapor Monitoring Wells

Three VMWs will be installed at the field test area to monitor for accumulations of methane and carbon dioxide and reductions of oxygen content in soil vapor. These data will provide a qualitative indication of microbial activity in the subsurface before and after vegetable oil injection. As shown on Figure 4.1, one VMW will be installed within the injection area and the second and third VMWs will be installed downgradient of the injection area. The newly installed VMWs will be screened in the vadose zone immediately above the seasonal high groundwater surface.

VMWs will be installed using direct push drilling (Geoprobe[®] or equivalent). The VMWs will be constructed of a 2-foot-long, 1-inch-inside diameter (ID) polyvinyl chloride (PVC) screen which will be flush threaded to 1-inch-diameter PVC solid riser casing. Solvents or adhesives will not be used during soil vapor probe assembly. The bottom of the VMW screens will be installed approximately 1 foot above the seasonal high groundwater level.

Each boring will be advanced to boring termination depth using 2-inch outside diameter (OD) Geoprobe[®] rods. After the rods are advanced to depth, the VMW will be installed inside the rods. After the VMW is installed, the rods will be withdrawn, and filter sand (#10-20) will be emplaced within the annular space between the outside of the PVC screen and the inside of the borehole to a level approximately 0.5 feet above the top of the PVC screen. The remaining annular space will be sealed with approximately 0.5 feet of bentonite chips immediately above the sand filter pack and concrete/bentonite grout from the top of the bentonite chip seal to approximately 1 foot below ground surface. The top of the casing will be finished with a sampling valve within a flush mounted road box type surface completion set in a concrete collar.

4.3.2 Substrate Injection Wells

Chlorinated solvents have a higher density than water and therefore tend to sink through more transmissive saturated zones and collect at the top of impermeable units that act as barriers to the downward migration of the chlorinated solvents. In addition, vegetable oil is less dense than water and therefore tends to migrate upward after injection. Thus, the lower portion of the Terrace Alluvium (Figure 2.3) is the target zone for injection of the soybean oil and lecithin in water emulsion.

The substrate will be injected using steel Geoprobe[®] rods and Geoprobe[®] SP-15[®] or SP-16[®] groundwater sampling tools. The substrate will be injected directly into the subsurface through the hollow Geoprobe[®] rods. After injection activities are complete at each injection point the Geoprobe[®] rods will be withdrawn and the borehole will be grouted with a concrete/bentonite grout slurry. The substrate will be injected within the TCE “hot spot” in the vicinity of existing monitoring wells WCHMHTA009 and WCHMHTA010 (Figure 4.1). The injection interval will extend from the top of the Walnut Formation bedrock to approximately seven feet above the top of the bedrock. The depth at which the Geoprobe[®] rig reaches refusal will be assumed to represent the top of the Walnut Formation. Typical well construction details are shown on Figure 4.2.

The Walnut Formation aquitard will not be penetrated during the installation of these injection points.

4.3.3 Groundwater Monitoring Wells

Ten 1-inch diameter PVC wells will be installed to monitor groundwater geochemical indicators and contaminant concentrations before and after substrate injection. The approximate placement of these GMWs is shown on Figure 4.1.

All of the GMWs will be screened in the basal portion of the Terrace Alluvium. Three of the GMWs will be installed within the injection area, to monitor short-term changes in groundwater chemistry resulting from the substrate injection. Additional GMWs will be installed ten feet (approximately one month advective travel time), 20 feet (approximately two months travel time), 50 feet (approximately six months travel time), and 100 feet (approximately 11 months travel time) downgradient from the injection area to monitor longer term changes in groundwater chemistry resulting from the substrate injection. In addition, existing cross-gradient monitoring wells WCHMHTA009 and WCHMHTA010 will be used to monitor background groundwater geochemical and contaminant conditions cross gradient from the injection area. Typical well construction details are shown on Figure 4.2. The Walnut formation aquitard will not be breached during the course of well installation activities associated with this pilot test. It is expected that well installation activities will take approximately three days to complete.

4.3.4 Soil Sampling

During drilling activities, soil samples will be collected from the ground surface to the total depth of two GMWs and described using the Burmeister modified Unified Soil Classification System (USCS). In addition, one soil sample will be collected from four of the monitoring wells and shipped to an offsite laboratory for TOC analysis via the Walkley Black Acid Digestion Method and VOC analysis via USEPA Method 8260B.

4.3.5 Investigation Derived Waste

The direct push drilling technique will be used to inject the substrate and install all of the monitoring wells. Therefore, soil investigation derived waste (IDW) generation is expected be minimal during this project. All purge water collected during development and baseline groundwater sampling activities will be containerized onsite, emulsified with the vegetable oil and fructose substrates, and re-injected into the subsurface via direct push Geoprobe[®] rods. It is assumed that groundwater IDW generated during the process monitoring events will be disposed of by the Base. The procedures that will be followed during injection are discussed in more detail in Section 4.6.

4.4 Well Development

All newly installed GMWs will be developed prior to substrate injection and groundwater sampling. Well development activities will commence at each well location at least 24 hours after the well is installed to give the concrete grout time to set. Wells will be developed by surging with a disposable bailer and removing a minimum of ten casing volumes of groundwater using a peristaltic pump (or similar) and disposable high

density polyethylene (HDPE) tubing. As the ten well casing volumes are removed, geochemical parameters (DO, temperature, pH, ORP, and electrical conductivity) will be monitored with a field instrument. The geochemical parameters will be allowed to stabilize in accordance with USEPA well development criteria.

4.5 BASELINE SAMPLING

Baseline groundwater sampling will be conducted immediately after well development activities have been completed. Table 4.1 details the initial site activities, sampling locations, and parameters to be measured during the baseline sampling event. The analytical protocols that will be utilized during all pilot test sampling activities are summarized on Table 4.2. Sampling will be performed before the substrate is injected. Baseline sampling will be used as the basis for comparison of groundwater and soil gas chemistry following substrate addition. It is expected that the baseline sampling activities will take approximately four days to complete.

4.5.1 Groundwater

Ten GMWs and two existing monitoring wells (WCHMHTA009 and WCHMHTA010) will be sampled for VOCs, electron acceptors (DO, nitrate, sulfate, and carbon dioxide), electron donors (TOC), metabolic by products (ferrous iron, methane, ethane, and ethene), and indicator parameters (pH, and ORP). Bromide will also be measured in existing cross gradient monitoring well WCHMHTA010 and one downgradient GMW. Baseline sample aliquots will also be collected and analyzed for volatile fatty acids (VFA) (seven samples) and phospholipid fatty acids (PLFA) (five samples). These groundwater samples will be used to define the pre-injection groundwater chemical conditions as well as to define the pre-injection microbial population present at the site.

All purge water generated during the course of well development and sampling activities (approximately 150 gallons) will be containerized in a large poly tank onsite for later re-injection during the vegetable oil injection phase of this pilot study. Approximately 3,850 gallons of additional groundwater will be extracted from onsite wells, including the newly installed monitoring and injection wells as well as previously installed wells, and added to the development and sampling water collected previously.

4.5.2 Soil Gas

Soil gas samples will be collected from the three newly installed VMWs. Soil gas sampling will consist of measuring oxygen, carbon dioxide, and methane content in the field using a field calibrated direct reading meter. Soil gas sampling results will be used to establish baseline soil gas conditions prior to substrate injection.

4.5.3 Substrate Sampling

One substrate sample will be collected from the vegetable oil before it is emulsified and injected into the subsurface. The substrate sample will be submitted to an offsite laboratory for VOC analysis via USEPA Method 8260B. This pre-injection vegetable oil

TABLE 4.2
SUMMARY OF BASELINE AND PERFORMANCE MONITORING
ANALYTICAL PROTOCOLS
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

MATRIX	METHOD	FIELD (F) OR ANALYTICAL LABORATORY (L)
Analyte		
SOIL VAPOR		
Methane, oxygen, carbon dioxide	Direct-reading meter	F
SOIL		
Total Organic Carbon	Walkley-Black ^{a/}	L
VOCs ^{b/}	SW8260B	L
WATER		
Redox Potential	Direct-reading meter	F
Dissolved Oxygen	Direct-reading meter	F
pH	Direct-reading meter	F
Specific Conductance	Direct-reading meter	F
Temperature	Direct-reading meter	F
Ferrous Iron	Colorimetric, Hach Method 8146 (or similar)	F
Manganese	Colorimetric, Hach Method 8034 (or similar)	F
Sulfide	Colorimetric, Hach Method 8131 (or similar)	F
Alkalinity (Carbonate [CO ₃ ⁻²] and Bicarbonate [HCO ₃ ⁻¹])	Titrimetric, Hach Method 8221 (or similar)	F
Chloride	Titrimetric, Hach Method 8225 (or similar)	F
Carbon Dioxide	Titrimetric, Hach Method 8205 (or similar)	F
Sulfate	E300.1	L
Nitrate [as Nitrogen (N)]	E353.1	L
Bromide	E320.1	L
Methane, Ethane, Ethene	AM-18 ^{a/}	L
Total Organic Carbon	SW9060 ^{a/}	L
VOCs ^{b/}	SW8260B	L
Volatile Fatty Acids	Microbial Insights SOP ^{c/}	L
Phospholipid Fatty Acids	Microbial Insights SOP ^{c/}	L
Dissolved Hydrogen	AM-20 ^{a/}	L
Dissolved Metals ^{d/}	SW6010	L
VEGETABLE OIL		
VOCs	SW8260B	L

^{a/} Microseeps Inc., standard operating procedure.

^{b/} VOCs = volatile organic compounds.

^{c/} SOP = standard operating procedure

^{d/} Metals = arsenic, selenium, manganese.

sample will be collected to ensure that the vegetable does not contain any VOC mass prior to injection and to provide baseline vegetable oil chemistry data.

4.5.3 Aquifer Testing

To evaluate the impact of the injection of the substrates on the hydraulic conductivity of the aquifer, a method for measuring *in situ* hydraulic conductivity will be applied at four locations during the field test program. Before the injection of the substrate, the hydraulic conductivity of the aquifer will be measured in two GMWs located within the injection area, and two GMWs located immediately downgradient of the injection area. Immediately after injection activities are complete the hydraulic conductivity will be re-measured in the two monitoring wells located downgradient of the injection area. Hydraulic conductivity testing will be repeated at the same four well locations during each process monitoring event to document long term changes in hydraulic conductivity.

Hydraulic conductivity measurements will be performed the method described by Wilson *et. al.* (1997), standard rising and falling head slug tests, or using a single well drawdown test (Appendix C).

4.6 SUBSTRATE DISTRIBUTION PLAN

A soybean oil, lecithin, and fructose emulsion in water will be injected into the “hot spot” of the North Lobe dissolved chlorinated solvent plume in the vicinity of existing monitoring wells WCHMHTA009 and WCHMHTA010 through an array of eight direct injection points. The substrate injection will be accomplished by first collecting a total of approximately 4,000 gallons of groundwater from the injection area and containerizing it onsite in large tanks. The containerized groundwater will then be amended with high fructose corn syrup and sodium bromide (NaBr). After the water has been amended with fructose and the NaBr tracer a small volume of amended water (approximately 50 gallons) will be injected into each injection point to distribute the fructose and NaBr tracer into the aquifer matrix ahead of the vegetable oil. After the initial amended water injection is completed at each point, vegetable oil will be added to the water and forced at pressure through an inline mixer to form an oil-in-water emulsion. This emulsion will then be injected directly into the subsurface through the Geoprobe® Rods. The emulsion injection will be followed at each injection point by a “water push” which will consist of approximately 50 gallons of water amended with fructose and NaBr. The water push will be injected to force the oil-in-water emulsion away from the injection point and thereby improve the dispersion of the emulsion away from the substrate injection locations and into the aquifer matrix. All make-up water that will be injected during substrate injection activities will be obtained from wells in the immediate vicinity of the pilot test area. The proposed substrate injection is summarized in Table 4.3.

4.6.1 Substrates and Tracers

4.6.1.1 Substrates:

Fructose is a food-grade product that can be obtained in bulk quantity locally and shipped to NAS Fort Worth JRB in sealed containers. High fructose corn syrup will be purchased from a local food distributor during the mobilization phase of this project.

TABLE 4.3
PROPOSED INJECTION SCENERIO
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Well	Pre-Vegetable Oil		Emulsion Mixture					Post- Vegetable Oil		Total		Final Percent Substrate	Injection Interval (feet)	Radius of Influence ^{a/} (feet)	Oil Injection Flow Rate (gpm) ^{c/}	Total Injection Time ^{b/} (hours)
	Water+Fructose Injection		Water+Fructose+Vegetable Oil Injection					Water+Fructose Injection		Volume						
	Water (gallons)	Fructose (pounds)	Oil (pounds)	(gallons)	Fructose (pounds)	Water (gallons)	Emulsifying Agent	Water (gallons)	Fructose (Pounds)	Substrate (Pounds)	Water (Gallons)					
PES-INJ-1	50	4	390	50	15	400	Lecithin ^{d/}	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-2	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-3	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-4	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-5	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-6	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-7	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
PES-INJ-8	50	4	390	50	15	400	Lecithin	50	4	413	500	98.0	7	5.0	4.0	2.1
TOTAL:	400	33	3120	400	120	3200		400	33	3,306	4000	98.0				17
Final Percent Substrate:		10.5	Final Fructose Concentration:					6 grams/liter								
Final Percent Water:		89.5	Final Oil Concentration:					94 grams/liter								

^{a/} Assumes an effective porosity of 15 percent.

^{b/} Assumes emulsion is injected into one injection well at a time.

^{c/} gpm = gallons per minute.

^{d/} Lecithin will be mixed with the oil at a ratio of 1 part lecithin to 9 parts vegetable oil.

Fructose is a water soluble substrate that will be distributed during injection through the aquifer matrix much more quickly and readily than the vegetable oil substrate. After injection the fructose mass will remain in the dissolved phase and will be transported by advective groundwater flow through the pilot test area. Fructose makes up only a small portion of the substrate mass that will be injected as it is intended that the fructose mass be consumed before it migrates beyond the pilot test area. Fructose will be mixed into the extracted water such that the final injected fructose mass will represent approximately 5 percent of the total substrate mass and approximately 0.5 percent of the total injection fluid volume.

The fructose will provide a highly soluble source of carbon to the *in-situ* microbial population more quickly and over a wider area than the vegetable oil substrate, thereby increasing the initial impact of the injection to site groundwater chemistry. The fructose will thus serve to pre-condition the chemistry of the groundwater system such that as the vegetable oil begins to breakdown and organic carbon and hydrogen are released into the system, the groundwater chemistry will already be conducive to reductive dechlorination. After the fructose is consumed, the vegetable oil will maintain the anaerobic geochemical conditions induced by the degradation of the fructose by providing a long-term source of organic carbon and hydrogen.

Food-grade soybean oil and liquid lecithin will be obtained from a commercial supplier such as Central Soya Company, Inc. of Fort Wayne, Indiana. Vegetable oil and lecithin are food-grade materials extracted from soy beans and are used in the food industry for a wide variety of applications. A soybean oil-lecithin mixture with a ratio of 10 pounds soybean oil to 0.25 pound lecithin will be prepared by the vendor prior to shipment to NAS Fort Worth JRB. Pure soybean oil/lecithin emulsion will be shipped in 55-gallon drums.

Soybean oil is relatively insoluble in water, thus lecithin is added as an emulsification agent so that the soybean oil can be emulsified with water prior to injection. This emulsification step is taken to increase the injection volume (1 part oil and 9 parts water) without increasing the vegetable oil volume. The result is that a relatively small volume of vegetable oil (400 gallons) can be distributed into a relatively large volume of aquifer matrix (4000 gallons). Thereby distributing vegetable oil such that the vegetable oil occupies only a small portion (10%) of the interstitial void spaces of the aquifer matrix. In this way a flow-through treatment bio-barrier is developed that allows groundwater to continue to flow through the barrier, bringing dissolved contaminant mass with it for treatment within the treatment zone.

After injection the vegetable oil-in-water emulsion will ultimately break and be distributed as small droplets of oil trapped within the aquifer matrix. This entrapped oil does not migrate with advective groundwater flow, rather it remains in place as a relatively immobile, slowly soluble, long-term source of organic carbon.

4.6.1.2 Hydrophilic Groundwater Tracer

To monitor the movement of groundwater along and away from the SIWs, NaBr tracer will be used. NaBr is a salt with high solubility in water that can be readily monitored in the lab or with field instrumentation. NaBr will be metered and mixed into the

groundwater extracted from the site prior to injection, or flushing of the substrate. A tracer concentration of approximately 500 mg/L will be introduced so that the presence of the bromide ion (Br^-) will be detectable in groundwater sampled from the downgradient monitoring wells.

4.6.2 Substrate Preparation

A static in-line mixer will be used to emulsify the soybean oil-lecithin mixture and groundwater, amended with NaBr tracer and fructose, that was previously drawn from the newly installed wells and existing monitoring wells onsite (WCHMHTA009 and WCHMHTA010) prior to injection. The emulsion will have an average droplet size slightly smaller than the average pore throat size of the aquifer matrix as reported for similar materials in published literature. The in-line mixer will be capable of shearing the soybean oil-lecithin mixture into an emulsion with droplets averaging five to ten micrometers (μm) in diameter.

4.6.3 Substrate Emplacement

Injection details are summarized in Table 4.3. Substrate injection will be performed by driving a Geoprobe SP-15 or SP-16 Groundwater Sampler[®] to a total depth of approximately 24 feet bgs. After the sampler is driven to depth the Geoprobe[®] rod will be retracted approximately 42 inches to expose the entire length of the sampling screen to the aquifer matrix.

After the screen is exposed, approximately 25 gallons of water, amended with NaBr tracer and fructose, will be injected into the subsurface through the Geoprobe[®] rod at approximately 4.0 gallons per minute (gpm) to test the system's functionality and to distribute fructose amended water out into the aquifer matrix. During that period, system pressures will be monitored and flow rate adjustments made as needed to avoid excessive pressure which could constitute a health and safety hazard. Removal of all air from the system will be ensured by checking air release vents installed on the injection well riser. A diagram of the injection system is depicted on Figure 4.3. Once this initial volume of water is injected, the vegetable oil will be metered into the injection system upstream of the inline mixer at a rate appropriate to produce an oil-in-water emulsion consisting of approximately 9 percent vegetable oil, 1 percent fructose, and 90 percent water. After approximately 225 gallons of the emulsion is injected into the subsurface the vegetable oil flow will be stopped and approximately 25 gallons of water amended with fructose will be injected into the point to flush the remaining emulsion out of the injection system and to improve the distribution of the substrate in the sub-surface. After this volume of water has been injected, the injection system will be shut down and the injection hoses will be disconnected from the Geoprobe[®] rod. The Geoprobe[®] rod will then be pulled up approximately 42 inches and the injection procedure will be repeated. The total injection interval of each injection location will be approximately 84 inches (7 feet) and the total injection volume for each injection point will be approximately 550 gallons of vegetable oil, fructose, and water. After injection procedures are complete the Geoprobe rods will be removed and the injection boreholes will be abandoned with cement/bentonite grout.

The substrate injection activities will begin by installing all of the injection points. After all of the injection points are installed, substrate will be injected into the injection



points in the following order: PES-INJ-01, PES-INJ-05, PES-INJ-02, PES-INJ-06, PES-INJ-03, PES-INJ-07, PES-INJ-04, and PES-INJ-08. It is expected that injection will take approximately 2 to 3 days.

Assuming the above volumes of emulsion/water mixture can be successfully injected into the formation equally and radial along the entire length of each injection screen, and assuming 15 percent effective porosity in the subsurface, this should provide a column of substrate (evenly distributed as droplets throughout the aquifer material) approximately 10.0 feet in diameter (5.0 foot radius) around each point of injection. The effective substrate saturation in the subsurface after injection is complete is targeted at approximately 10.5 percent of the effective porosity. After the injection process has been completed, the presence of phase-separated oil emulsion in the GMWs and the impact on the groundwater table elevation will be measured with an oil-water interface probe.

4.7 PERFORMANCE MONITORING

Performance monitoring activities will be conducted periodically following substrate injection in order to determine the effectiveness of organic substrate addition to enhance the reductive dechlorination of chlorinated solvents in groundwater at the pilot test area. Performance monitoring activities are summarized in Table 4.4 and will adhere to analytical protocols summarized in Table 4.2.

During each process monitoring event all of the newly installed monitoring wells and two existing wells will be sampled for various parameters. Performance monitoring activities will be conducted approximately 6 months and 12 months after injection activities are complete.

TABLE 4.4
SUMMARY OF PROPOSED PROCESS MONITORING ACTIVITIES
SUBSTRATE INJECTION PILOT TEST
AREA OF CONCERN 2
NAS FORT WORTH JRB, TEXAS

Location	Approximate Screened Interval (ft bgs) ^{a/}	Aquifer Tests	Water Level Measurement	Soil Vapor Analyses	Groundwater Analyses										
				Methane, Oxygen, Carbon Dioxide (Field Meter)	VOCs ^{b/} SW8260B	Methane, Ethane, Ethene (AM-18/20GAX)	Nitrate (E353.1)	Bromide (E320.1)	Chloride, Sulfate (E300.1)	Total Organic Carbon (SW9060)	Dissolved Metals ^{c/} (SW6010)	Volatile Fatty Acids	Phospholipid Fatty Acids	Well Head Analyses ^{d/}	Mobile Lab Analysis ^{e/}
Soil Gas Monitoring Points															
PES-VMP-01	4 - 6			1											
PES-VMP-02	4 - 6			1											
PES-VMP-03	4 - 6			1											
Groundwater Monitoring Points															
PES-GMW-01	10 - 25	1	1		1	1	1	1	1	1		1	1	1	1
PES-GMW-02	10 - 25	1	1		1	1	1	1	1	1	1			1	1
PES-GMW-03	10 - 25	1	1		1	1	1	1	1	1		1		1	1
PES-GMW-04	10 - 25		1		1	1	1	1	1	1		1	1	1	1
PES-GMW-05	10 - 25		1		1	1	1	1	1	1				1	1
PES-GMW-06	10 - 25	1	1		1	1	1	1	1	1		1	1	1	1
PES-GMW-07	10 - 25	1	1		1	1	1	1	1	1	1	1	1	1	1
PES-GMW-08	10 - 25		1		1	1	1	1	1	1				1	1
PES-GMW-09	10 - 25		1		1	1	1	1	1	1		1		1	1
PES-GMW-10	10 - 25		1		1	1	1	1	1	1				1	1
Existing Monitoring Wells															
WCHMHTA009	4.5 - 12		1	1	1	1	1	1	1	1	1			1	1
WCHMHTA010	15 - 25		1		1	1	1	1	1	1		1	1	1	1
Injection Locations															
SUBTOTALS		5	12	4	12	12	12	12	12	12	3	7	5	12	12
QA/QC															
Duplicates					1										1
Matrix Spike					1										
Matrix Spike Duplicate					1										
Trip Blanks					2										
TASK TOTAL:				4	17	12	12	12	12	12	3	7	5	12	13

^{a/} ft bgs = feet below ground surface.
^{b/} VOCs to include aromatic and chlorinated aliphatic hydrocarbons.
^{c/} Dissolved metals analysis will include arsenic, manganese, and selenium.
^{d/} Well head analyses include dissolved oxygen, oxidation-reduction potential, pH, temperature, and electrical conductivity.
^{e/} Mobile lab analyses include carbon dioxide, chloride, alkalinity, sulfide, ferrous iron, and manganese.

SECTION 5

PROPOSED SCHEDULE

The milestones and time required for the implementation of the tasks outlined in this work plan are as follows:

TASK	Duration	Completion Date
Work Plan Submittal	--	April 9, 2003
Site Visit	1 day	December 18, 2002
Work Plan Review	4 weeks	May 7, 2003
Final Work Plan	4 weeks	July 8, 2003
Initiation of Field Activities		
Mobilization	1 day	July 28, 2003
Installation of monitor wells and soil gas points	3 days	
Well development	2 days	
Baseline sampling of monitor wells & hydraulic conductivity measurements	3 days	
Injection of Vegetable Oil-in-Water Emulsion	3 days	August 5, 2003
Demobilization	1 day	August 8, 2003
Process Monitoring Round 1	5 days	February 16, 2004
Process Monitoring Round 2	5 days	August 23, 2004

SECTION 6

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APPENDIX A

PROGRAM HEALTH AND SAFETY PLAN

**PROGRAM HEALTH AND SAFETY PLAN
FOR ENHANCED IN SITU BIOREMEDIATION OF
HALOGENATED COMPOUNDS**

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

AFCEE CONTRACT F41624-00-D-8024, DO-0011

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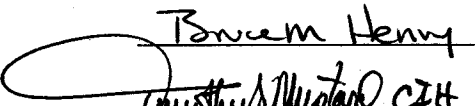
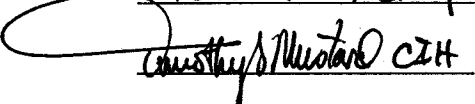
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SECTION 1

PURPOSE AND POLICY

The purpose of this program health and safety plan is to establish protection standards and mandatory safety practices for all Parsons Engineering Science, Inc. (Parsons ES) and subcontractor personnel involved in enhanced bioremediation pilot tests at several United States Air Force installations. The goal of this safety program is to conduct the entire project with **zero accidents**. All task activities shall be designed for zero accidents. This plan provides guidance for safe operations on enhanced bioremediation pilot test sites and provides for contingencies that may arise during field operations. Site-specific information is not included in this plan and will be addressed in the formal health and safety plan addenda. All Parsons ES field team members and subcontractors are responsible for reading and conforming to this plan and the associated addenda. All personnel will be required to sign the Plan Acceptance Form located in Appendix B. No employee will perform a project activity that he or she believes may endanger his or her health and safety or the health and safety of others.

All personnel must share responsibility in performing all work in such a manner and under such conditions to preclude or minimize the possibility of damage to property or injury to themselves or others. Carelessness or disregard of accepted safety, health, and fire protection standards will not be tolerated. Any field team member who does not comply with established safety procedures will be subject to immediate dismissal from the site.

A project description and scope of work summary for the project are provided in Section 2. Section 3 presents the project team organization, personnel responsibilities,

and lines of authority. Training and medical monitoring requirements are contained in Section 4. Section 5 presents a safety and health risk analysis. Section 6 contains the program emergency response plan. Program requirements for levels of protection are included in Section 7, and air monitoring procedures are provided in Section 8. Site control measures, including designation of site work zones, are contained in Section 9, and Section 10 provides decontamination procedures. Section 11 contains information on the use and calibration of air monitoring equipment. Appendix A contains an example of an Emergency Contacts Form to be used in each formal health and safety plan addendum prepared for all investigation sites. Appendix B contains a Plan Acceptance Form, Site-Specific Training Record Form, Field Experience Documentation Form, Air Monitoring Data Forms, Accident Report Form, Near-Miss Incident Form, Shipping Paper, Daily Vehicle Inspection Report, and Respirator Use Forms. Appendix C contains job analyses for project activities.

SECTION 2

PROJECT DESCRIPTION AND SCOPE OF WORK

2.1 PROJECT DESCRIPTION

Under this delivery order (DO), Parsons ES will provide services to the U.S. Air Force Center for Environmental Excellence (AFCEE) through the contract Parsons ES has with AFCEE to demonstrate the use of enhanced bioremediation via vegetable oil injection and bark mulch permeable reaction zones to reduce concentrations of solvents (chlorinated aliphatic hydrocarbons) in the groundwater and soil at various Air Force installations nationwide.

2.2 SCOPE OF WORK

Site activities will include use of direct push technologies to include the Geoprobe[®] direct-push technology or cone-penetrometer technology (CPT); monitoring and injection point installation; vegetable oil injection; continuous trenching; soil, oil, and groundwater sampling; and aquifer testing. Field work is expected to begin in December 2000 and will be completed in December 2001.

SECTION 3

PROGRAM TEAM ORGANIZATION

The Parsons ES team assigned to the bioremediation treatability studies project, their responsibilities, and lines of authority are outlined below.

<u>Name</u>	<u>Task Assigned</u>
Mr. Doug Downey, P.E.	Technical Manager
Mr. Todd Wiedemeier, P.G.	Technical Director
Mr. Bruce Henry, P.G.	Project Manager
Mr. Timothy Mustard, C.I.H.	Program Health and Safety Manager
Mr. Steven Hicks	Whiteman AFB Site Manager
Mr. Ted Hartfelder	Cape Canaveral Site Manager
Mr. Scott Hoxworth	Assistant Cape Canaveral Site Manager
To be assigned	Site Health and Safety Officers
To be assigned	Alternate Health and Safety Officers
Mr. Patrick Haas	AFCEE Contracting Officer's Technical Representative (COR)

The technical director and manager, Mr. Doug Downey and Mr. Todd Wiedemeier, are responsible for conduct and review of all technical work on this project to ensure technical accuracy and adequacy. They will provide advice to the project manager and project personnel on technical issues.

The project manager, Mr. Bruce Henry, is directly responsible for the execution of all phases of this project. He is responsible for planning, staffing, assuring adequate planning for health and safety and quality assurance/quality control (QA/QC), execution of each phase, coordination with AFCEE, and interpretation of data and reporting. The

project manager will also coordinate with the site manager to obtain permission for site access, coordination of activities with appropriate officials, and serve as the liaison with public officials. The project manager will also ensure that quality work is accomplished on schedule.

The program health and safety manager, Mr. Timothy Mustard, will ensure that all field activities are performed with strict adherence to OSHA requirements and this program health and safety plan. He will be responsible for updating and revising the program health and safety plan, as needed, and for ensuring that all field team members meet health and safety training and medical monitoring requirements.

The site health and safety officer (SHSO) along with the project manager is responsible for ensuring that day-to-day project activities are performed in strict conformance with the program health and safety plan. Through action and example, the SHSO will instill a sincere attitude toward the zero accident philosophy for this program, and will help field personnel develop a better understanding of accident prevention and loss control. The SHSO, project manager, and program health and safety manager have the authority to stop work if actions or conditions are judged to be unsafe or not in conformance with the program health and safety plan.

The site manager will support the project manager for the specific work the team will accomplish at each site and will be responsible for scheduling and coordinating the testing activities at the respective sites. The site manager will assist the project manager in the day-to-day organization and execution of the various project tasks. The site manager will also apply the zero accident philosophy in designing field tasks. He will use any downtime in the field for safety training and educational purposes, to the extent possible.

SECTION 4

SITE-SPECIFIC EMPLOYEE TRAINING AND MEDICAL MONITORING REQUIREMENTS

The Parsons ES corporate health and safety manual, incorporated by reference, presents general requirements for Parsons ES employee training and medical monitoring. All field team members will have completed the 40-hour basic health and safety training as specified by the Occupational Safety and Health Administration (OSHA) in Title 29, Code of Federal Regulations, Part 1910.120, paragraph (e) (29 CFR 1910.120[e]) and the 8-hour annual refresher training thereafter. All supervisory personnel onsite will be required to have completed an 8-hour supervisor course as required in 29 CFR 1910.120(e).

In addition to the 40-hour course, all field employees will be required to have completed a minimum of 3 days onsite training under the supervision of a trained and experienced supervisor, not necessarily at one of the current investigation sites. If this training is received during a current bioremediation treatability study, the training will be documented on the Field Experience Documentation Form provided in Appendix B. Employees will not participate in field activities until they have been trained to the level required by their job function and responsibility. In addition, at least one person on every Parsons ES field crew will have current certification in Red Cross or equivalent first-aid and cardiopulmonary resuscitation (CPR). All training documentation for Parsons ES personnel will be verified by the SHSO and maintained by the health and safety manager.

All Parsons ES field team members will be on current medical monitoring programs in accordance with federal OSHA requirements (29 CFR 1910.120) and Parsons ES

corporate policies. Listed below are additional health and safety training and medical monitoring requirements for this project.

4.1 ADDITIONAL SAFETY TRAINING REQUIREMENTS

If Level B (self-contained breathing apparatus [SCBA]) respiratory protection is used, additional training may be required for those personnel involved. This training will be conducted onsite as necessary by a qualified, Level B-experienced supervisor. Employees will also be trained in use, care, maintenance, limitations, and disposal of personal protective equipment (PPE) in accordance with 29 CFR 1910.132. All field team members must have site-specific training as discussed in the following subsection.

4.1.1 Site-Specific Safety Training

Site-specific safety and health training will be conducted by the Parsons ES SHSO for all personnel who will engage in any field work under this contract. Site-specific safety training will address the activities, procedures, monitoring, and equipment applicable to the site operations, as well as site or facility layout, potential hazards, and emergency response services at the site. Additional topics that will be addressed at the safety briefings will include:

- Names of responsible health and safety personnel;
- Zero accident performance philosophy
- Identification of site hazards and measures for eliminating or reducing hazard risk;
- Site contingencies and emergency procedures;
- Exposure risk;
- Symptoms of exposure and exposure treatment for chemical contaminants;
- Use, care, maintenance, and limitations of PPE;

- Decontamination procedures to be followed;
- Location of safety equipment;
- Review of planned activities and specialized training necessary for personnel to perform their work with zero accidents;
- Defined safety procedures to be followed during field activities; and
- Emergency and evacuation procedures.

4.1.2 Daily Safety Briefings

Daily safety briefings will also be conducted prior to commencement of field activities. Discussion and coordination of field team activities, discussion of hazards faced that day, and discussion of hazard mitigation procedures will be held with all field team members. Documentation of training and briefings, including agenda and signatures of attending personnel, will be maintained onsite. Site-specific training forms are provided in Appendix B.

4.2 MEDICAL MONITORING REQUIREMENTS

Prior to being assigned to the field activities, each Parsons ES employee will receive a preassignment or baseline physical examination. Preassignment screening has two major functions: 1) determination of an individual's fitness for duty, including the ability to perform work while wearing PPE; and 2) provision of baseline data for comparison with future medical data. Medical qualification/certification documentation will be maintained by the program health and safety manager. All medical examinations and procedures will be performed by or under the supervision of a licensed physician, preferably an occupational physician. The examination content will be determined by the examining physician in accordance with 29 CFR 1910.120(f).

SECTION 5

SAFETY AND HEALTH RISK ANALYSIS AND HAZARD MITIGATION

5.1 CHEMICAL HAZARDS

The chemicals of primary concern occurring at the bioremediation sites include chlorinated solvents. In particular, the chlorinated solvents tetrachloroethene (PCE), trichloroethene (TCE), isomers of dichloroethene (DCE), and vinyl chloride. In addition, petroleum fuels and the associated petroleum hydrocarbon constituents benzene, toluene, ethylbenzene, and xylenes (BTEX) may also be encountered.

Table 5.1 summarizes the health hazards and properties of the aforementioned compounds. If other compounds are discovered at these sites, the pertinent information about these compounds will be provided in Table 5.1 of the site-specific addenda. The health hazards or other physical/chemical hazards (e.g., corrosiveness, flammability) of the compounds will then be communicated to the onsite employees.

Hazardous substances of primary concern identified are those potentially occurring in contaminated groundwater, soils, or air.

5.2 PHYSICAL HAZARDS

In addition to the hazardous substances potentially present at the sites, other physical hazards or hazardous conditions may be expected at the sites during the course of performing investigation or remediation activities. These hazards include possible risks from injury while working around motor vehicles including the auger drilling rig, Geoprobe® unit, stationary or moving equipment, fire or explosion hazards, slip, trip, and

TABLE 5.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
Benzene	1 (29 CFR 1910.1028) ^{f/}	0.5 (skin) ^{g/}	500	4.7	9.24	Colorless to light-yellow liquid (solid<42°F) with an aromatic odor. Eye, nose, skin, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, anorexia, exhaustion, dermatitis, bone marrow depression, and leukemia. Mutagen, experimental teratogen, and carcinogen.
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA ^{h/}	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.
Diesel Fuel	400 ^{i/}	400 ^{i/}	1,100 ^{i/}	0.08	NA	Colorless to brown, slightly viscous liquid with a gasoline- or kerosene-like odor. Irritates eyes, nose, and throat. Causes dizziness, drowsiness, headaches, nausea, dry cracked skin, and chemical pneumonia.
Ethylbenzene	100	100	800 (10% LEL) ^{j/}	0.25-200	8.76	Colorless liquid with an aromatic odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. Mutagen and experimental teratogen.
Gasoline	300	300	NA	0.005-10	NA	Clear/amber flammable, volatile liquid with a characteristic odor. Irritate eyes, skin, and mucous membranes. Causes dermatitis, headaches, fatigue, blurred vision, dizziness, slurred speech, confusion, convulsions, chemical pneumonia, and possible liver and kidney damage. In animals, causes liver and kidney cancer. Monitor for BTEX constituents. Carcinogen.
Jet Fuel	400 ^{i/}	400 ^{i/}	1,100 ^{i/}	0.08-1	NA	Colorless to light-brown liquid with a fuel-like odor. Long-term effects include liver, kidney, and CNS damage. JP-4 is a questionable carcinogen.
2-Methylnaphthalene	NA	NA	NA	0.003-0.04	7.96	Colorless gas or solid with a disagreeable garlic or rotten cabbage odor. Irritates eyes, skin, nose, and throat.
Naphthalene	10	10	250	0.3	8.12	Colorless to brown solid (shipped as a molten liquid) with a mothball-like odor. Irritates eyes, skin, and bladder. Causes headaches, confusion, excitement, convulsions, coma, vague discomfort, nausea, vomiting, abdominal pain, profuse sweating, jaundice, hematoma, hemoglobin in

TABLE 5.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
						the urine, renal shutdown, dermatitis, optic nerve disorders, and corneal and liver damage. Experimental teratogen and questionable carcinogen.
Perchloroethylene (Tetrachloroethene or PCE)	25 ^{k/}	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Toluene	100	50 (skin)	500	0.2-40 ^{l/}	8.82	Colorless liquid with sweet, pungent, benzene-like odor. Irritates eyes and nose. Causes fatigue, weakness, dizziness, headaches, hallucinations or distorted perceptions, confusion, euphoria, dilated pupils, nervousness, tearing, muscle fatigue, insomnia, skin tingling, dermatitis, bone marrow changes, and liver and kidney damage. Mutagen and experimental teratogen.
1,1,1-Trichloroethane (TCA) (Methyl Chloroform)	350	350	700	20-500	11.00	Colorless liquid with a mild chloroform-like odor. Irritates eyes and skin. Causes headaches, exhaustion, CNS depression, poor equilibrium, dermatitis, liver damage, cardiac arrhythmia, hallucinations or distorted perceptions, motor activity changes, aggression, diarrhea, and nausea or vomiting. Mutagen, experimental teratogen, and questionable carcinogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Vinyl Chloride	1 (29 CFR 1910.1017) ^{f/}	1	NA	260	9.99	Colorless gas (liquid <7°F) with a pleasant odor at high concentrations. Severe irritant to skin, eyes, and mucous membranes. Causes weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or blue skin on the extremities, liver cancer, and frostbite (liquid). Also attacks lymphatic system. Mutagen, experimental teratogen, and carcinogen.
Xylene (o-, m-, and p-isomers)	100	100	900	0.05-200 ^{k/}	8.56 8.44 (p)	Colorless liquid with aromatic odor. P-isomer is a solid <56°F. Irritates eyes, skin, nose, and throat. Causes dizziness, drowsiness, staggered gait, incoordination, irritability, excitement, corneal irregularities, conjunctivitis, dermatitis, anorexia, nausea, vomiting, abdominal pain,

TABLE 5.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
						and olfactory and pulmonary changes. Also targets blood, liver, and kidneys. Mutagen and experimental teratogen.

- a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1994. Some states (such as California) may have more restrictive PELs. Check state regulations.
- b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), 1999 *TLVs* ® and *BEIs* ®.
- c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1994.
- d/ When a range is given, use the highest concentration.
- e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.
- f/ Refer to expanded rules for this compound.
- g/ (skin) = Refers to the potential contribution to the overall exposure by the cutaneous route.
- h/ NA = Not available.
- i/ Based on exposure limits for petroleum distillates (petroleum naphtha).
- j/ Indicates that the IDLH value was based on 10% of the lower explosive limit for safety considerations, even though relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations (*NIOSH Pocket Guide to Chemical Hazards*, 1997).
- k/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.
- l/ Olfactory fatigue has been reported for the compound and odor may not serve as an adequate warning property.

fall hazards; electrical hazards; and excessive noise conditions. Additional physical hazards include heat stress and cold-related exposures.

The guidelines presented in this section are applicable to all types of equipment that may be used during field activities at the Air Force installations. Individual equipment types or certain specialized equipment may require additional safety considerations or specialized training prior to its use. Should any specialized equipment be required during the performance of a task, the program health and safety manager will ensure that operators receive appropriate training. The program health and safety manager is also responsible for ensuring that all equipment is routinely inspected and that any piece of equipment considered unsafe is not used until the unsafe conditions are corrected or repaired.

5.2.1 Heavy Equipment, Trenching Rigs, and Drilling Rigs

Working with large motor vehicles could be a major hazard at these sites. Injuries can result from equipment dislodging and striking unsuspecting personnel, and impacts from flying objects or overturning of vehicles. Vehicles and heavy equipment design and operation will be in accordance with 29 CFR, Subpart O, 1926.600 through 1926.602. In particular, the following precautions will be used to help prevent injuries and accidents:

- Daily vehicle inspections will be conducted and documented.
- Do not back up large motor vehicles unless the vehicle has backup warning lights and a reverse signal alarm audible above the surrounding noise level, or an observer signals it is safe to do so.
- No riders other than the driver are permitted on heavy equipment.
- Motor vehicle cabs will be kept free of all nonessential items and all loose items will be secured.
- Drilling rig masts will be lowered to the ground and parking brakes will be set before shutting off the vehicle.

- Drilling rig brakes, cables, kill switches, hydraulic lines, light signals, fire extinguishers, fluid levels, steering, tires, horn, and other safety devices will be inspected daily.
- All personnel working at and around the drilling rig must be informed of the locations of the kill switches.
- Only qualified operators will be allowed to operate heavy equipment.
- When heavy equipment is left unattended, loads must be lowered, controls neutralized, power shut off, and brakes set. Wheels must be chocked if a vehicle is parked on an incline.

When working near a backhoe or excavator, field personnel will maintain sight contact with the operator. Field personnel shall not work within the swing radius of the backhoe boom while the equipment is operating. The swing radius will be defined by fully extending the boom and defining the radius with traffic cones, barrier tape, or other suitable means, such as inscribing the radius on the soil surface using the bucket. Personnel will not cross the demarcated line without first establishing eye contact with the operator. The operator will lower the bucket to the ground on either side of the trench and remove his hands and feet from the controls and/or turn the backhoe off, before allowing personnel access to the area within the swing radius of the backhoe arm. Backhoe operations will resume only after all personnel have left the area within the swing radius.

When working near a drill rig, personnel shall be aware of snag hazards from rotating tools and pinch and crush hazards from suspended tools. No loose, dangling clothing will be allowed. Personnel will also be aware of falling object hazards and wear hard hats at all times. Personnel will be aware of slip, trip, and fall hazards from drilling equipment, tools, and well construction materials that may be lying on the ground in the vicinity of the drill rig. To reduce the threat of slip, trip, and fall hazards, the area immediately around the drill rig will be kept clear of equipment and supplies. Use of a downhole

hammer will require the use of an air compressor. The compressor air hoses will be checked daily prior to startup for cracks or other defects that could result in injuries. Refer to Section 5.2.7 for noise associated with drill rig, downhole hammer, and air compressor.

5.2.2 Hazards Associated with the CPT or Geoprobe® Unit

The CPT and Geoprobe® units consists of a hydraulically-driven press mounted on the bed of a pick-up truck, with power supplied to the cylinder via a power-take-off on the truck. A list of safety instructions provided by the Geoprobe® manufacturer is provided below, and will be followed by all Parsons ES and subcontractor personnel.

- Never operate the controls without proper training.
- Always take the vehicle out of gear and set the emergency brake before engaging the remote ignition.
- If the vehicle is parked on a loose or soft surface, do not fully raise the rear of the vehicle with the probe foot, as the vehicle may fall or move, causing injury.
- Always extend the probe unit out from the vehicle, and deploy the foot to clear the vehicle roof line before folding the probe unit out.
- Operators must wear OSHA-approved steel-toed shoes, and keep feet clear of the probe foot.
- Only one person should operate the probe machine and assemble/disassemble the probe rods and accessories.
- Never place hands on top of a rod while it is under the machine.
- Turn off the hydraulic system while changing rods, inserting the hammer anvil or attaching accessories.

- While operating the controls, the operator must stand to the control side of the probe machine, clear of the probe foot and mast.
- Wear safety glasses at all times during the operation of this machine.
- Never exert down pressure on the probe rod so as to lift the machine base over six inches off the ground.
- Wear ear muffs or disposable foam earplugs when in the vicinity of the operation of equipment, aircraft noise or other sources of high intensity noise.

5.2.3 Support Vehicles

Contractor/subcontractor personnel shall wear seat belts and obey posted speed limits. Personnel shall comply with applicable state, local, and installation traffic regulations. Current or anticipated hazardous road conditions (i.e., ice, construction) will be addressed at the daily safety briefings. No personnel shall ride in the bed of pickup trucks or standing on the side or riding on the fenders of heavy equipment.

Personnel will conduct a "walk-around" inspection of the vehicle before moving it to ensure they do not drive over personnel or equipment.

No personally-owned vehicles (POVs) will be driven into contaminated areas, nor will contaminated equipment, personnel, or material be transported in POVs. POVs must be left in support zones on-site. Stunt driving, racing, and horseplay are prohibited and will be subject to disciplinary action, including dismissal.

5.2.4 Subsurface Hazards

Before intrusive field activities are performed, efforts must be made to determine if underground installations (i.e., sewers, and telephone, water, fuel, and electrical lines) will be encountered and if so, where such underground installations are located. The site manager will ensure that all underground installations have been identified prior to any intrusive operations.

5.2.5 Electrical Hazards

Some of the equipment used during bioremediation is powered by electricity. Maintenance and daily activities require personnel to use, handle, and control this equipment. Safe work practices must be strictly observed to avoid serious injury and death.

According to 29 CFR 1910.269(l), only qualified employees may work on or with exposed energized lines or parts of equipment, or in areas containing unguarded, uninsulated, energized lines or parts of equipment operating at 50 volts (V) or more. Qualified employees must be trained in accordance with 29 CFR 1910.269(a) and certified as such by the employer.

Ordinary 120 V electricity may be fatal. Extensive studies have shown that currents as low as 10 to 15 milliamps (mA) can cause loss of muscle control and that 12 V may, on good contact, cause injury. Therefore, all voltages should be considered dangerous.

Electricity can paralyze the nervous system and stop muscular action. Frequently, electricity may affect the breathing center at the base of the brain and interrupt the transmission of the nerve impulses to the muscles responsible for breathing. In other cases, the electrical current directly affects the heart, causing it to cease pumping blood. Death follows due to a lack of oxygen in the body. Therefore, a victim must be freed from the live conductor promptly by use of a nonconducting implement, such as a piece of wood, or by turning off the electricity to at least this point of contact. Bare hands should never be used to remove a live wire from a victim or a victim from an electrical source. Artificial respiration or CPR should be applied immediately and continuously until breathing is restored, or until a physician or emergency medical technician arrives.

General rules for recognizing electrical safety are provided below.

- Only authorized and qualified personnel will perform electrical installations or repairs.

- All electrical wires and circuits will be assumed to be "live," unless it can be positively determined they are not.
- Appropriate protective clothing will be worn by personnel performing electrical work.
- All electrical equipment will be properly grounded and class-approved for the location.
- Ground fault circuit interrupter receptacles and circuit breakers will be installed where required by the National Electric Code and 29 CFR 1926.404.
- Electrical control panels will not be opened unless necessary.
- No safety device will be made inoperative by removing guards, using oversized fuses, or by blocking or bypassing protective devices, unless it is absolutely essential to the repair or maintenance activity, and then only after alerting operating personnel and the maintenance supervisor.
- All power tools will have insulated handles, be electrically grounded, or be double insulated.
- Fuse pullers will be used to change fuses.
- Metal ladders, metal tape measures, and other metal tools will not be used around electrical equipment or overhead electrical lines.
- Wires and extension cords will be placed or arranged so as to not pose a tripping hazard.

5.2.6 Slip, Trip, and Fall Hazards

Existing site conditions may pose a number of slip, trip, and fall hazards, such as:

- Open excavations, pits, or trenches;

- Slippery surfaces;
- Steep or uneven grades;
- Surface obstructions; and
- Construction materials or debris.

The extension cords connecting pumps to power supplies also provide a trip and fall hazard. Caution must be exercised and unnecessary personnel should avoid the area of the cord.

All field team members will be instructed to be cognizant of potential safety hazards and immediately inform the SHSO or the site manager about any new hazards. If the hazard cannot be immediately removed, actions must be taken to warn site workers about the hazard. The site will be kept in a neat, organized, and orderly fashion. Rubbish, trash, or debris generated by the project team shall be picked up and properly disposed of on a daily basis. Items such as tools, equipment, and hoses will be properly stored when not in use.

5.2.7 Noise-Induced Hearing Loss

Work onsite may involve the use of equipment such as drilling rigs, downhole hammers, pumps, compressors, and generators. The exposure of unprotected site workers to this noise or to aircraft noise during site activities can result in noise-induced hearing loss. Heavy equipment can emit noise levels exceeding the federal OSHA time-weighted average (TWA) limit of 85 decibels (dB). Noise levels in the area of the drilling rig and Geoprobe® unit will be presumed in exceedance of the OSHA TWA, and hearing protection will be required. Foam ear plugs will generally provide adequate protection. The SHSO will ensure that either ear muffs or disposable foam earplugs are made available to, and are used by, all personnel in the vicinity of the operation of equipment, aircraft noise or other sources of high intensity noise.

5.2.8 Fire or Explosion Hazards

Fuels and solvents may have been released into the soils at the Army installations and vapors from these fuels may be flammable or explosive. Therefore, precautions will be taken when performing investigation and remediation activities to ensure that combustible or explosive vapors have not accumulated, or that an ignition source is not introduced into a flammable atmosphere.

OSHA standards for fire protection and prevention are included in 29 CFR Subpart F, 1926.150 through 1926.154. Of particular concern on these sites are:

- Proper storage of flammables;
- Adequate numbers of 20 lb A:B:C type fire extinguishers;
- Use of intrinsically safe (explosion-proof) equipment where appropriate; and
- Monitoring for development of an explosive atmosphere.

5.2.9 Electric Power Line Clearance and Thunderstorms

Above- and below-ground utility lines may pose a safety hazard to workers during excavation or drilling. Extra precautions will be exercised when drilling near electrical lines. The minimum clearance between overhead electrical lines of 50 kilovolts (kV) or less and the drill rig mast is 20 feet. The location of underground utilities must be determined prior to excavation or drilling. No drilling will take place without the identification of underground utility lines by a representative of the utility company(ies) or by the appropriate installation personnel. All permits, licenses, and/or rights-of-entry required by state, local, and/or installation authorities will be the responsibility of the contractor. Drilling operations and other tasks performed outdoors must cease during thunderstorms.

The SHSO will provide onsite surveillance of the drilling subcontractor to ensure that personnel meet these requirements. If deficiencies are noted, work will be stopped and

corrective actions implemented. Reports of health and safety deficiencies and the corrective actions taken will be forwarded to the installation manager by the SHSO.

5.2.10 Effects and Prevention of Heat Stress

Adverse weather conditions are important considerations in planning and conducting site operations. Hot or cold weather can cause physical discomfort, loss of efficiency, and personal injury. These conditions are discussed further below.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur. They can range from mild symptoms such as fatigue; irritability; anxiety; and decreased concentration, dexterity, or movement; to death. Medical help must be obtained for the more serious cases of heat stress. One or more of the following actions will help reduce heat stress:

- Provide plenty of liquids. To replace body fluids (water and electrolytes) lost due to perspiration, each employee must drink 1 to 1.5 gallons of water or commercial electrolyte mix per day. Workers are encouraged to frequently drink small amounts, i.e. one cup every 15-20 minutes.
- Field personnel are cautioned to minimize alcohol intake during off-duty hours.
- Provide cooling devices (e.g., water jackets or ice vests) to aid natural body ventilation. These devices, however, add weight, and their use should be balanced against worker mobility.
- Wear long cotton underwear, which acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.
- Install portable emergency showers and/or hose-down facilities to reduce body temperature and to cool protective clothing.
- In extremely hot weather, conduct nonemergency response operations in the early morning or evening.

- Ensure that adequate shelter is available to protect personnel against sun, heat, or other adverse weather conditions which decrease physical efficiency and increase the probability of accidents.
- In hot weather, rotate workers wearing protective clothing.
- Maintain good hygienic standards by frequent changing of clothing and daily showering. Clothing should be permitted to dry during rest periods. Workers who notice skin problems should immediately consult the SHSO.

5.2.10.1 Heat-Related Problems

- Heat rash: Caused by continuous exposure to heat and humid air, and aggravated by chafing clothes. Decreases ability to tolerate heat and is a nuisance.
- Heat cramps: Caused by profuse perspiration with inadequate fluid intake and chemical replacement, especially salts. Signs include muscle spasms and pain in the extremities and abdomen.
- Heat exhaustion: Caused by increased stress on various organs to meet increased demands to cool the body. Signs include shortness of breath; increased pulse rate (120-200 beats per minute); pale, cool, moist skin; profuse sweating; and dizziness and exhaustion.
- Heat stroke: The most severe form of heat stress. Body must be cooled immediately to prevent severe injury and/or death. Signs include red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and possibly coma. Medical help must be obtained immediately.

5.2.10.2 Heat-Stress Monitoring

Monitoring of personnel wearing impermeable clothing will begin when the ambient temperature is 70°F (21°C) or above. Table 5.2 presents the suggested frequency for such monitoring. Monitoring frequency will increase as the ambient temperature increases or

as slow recovery rates are observed. Heat-stress monitoring will be performed by a person with current first-aid certification who is trained to recognize heat-stress symptoms. For monitoring the body's recuperative capabilities in response to excess heat, one or more of the techniques listed below will be used. Other methods of heat-stress monitoring may also be used, such as the wet-bulb globe temperature index from the current edition American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) Booklet.

To monitor the worker, measure:

- Heart rate: Count the radial pulse during a 30-second period as early as possible during the rest period.
 - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, the next work cycle will be shortened by one-third and the rest period will remain the same.
 - If the heart rate still exceeds 110 beats per minute at the next rest period, the following work cycle will be reduced by one-third.
- Oral temperature: Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).

TABLE 5.2
SUGGESTED FREQUENCY OF PHYSIOLOGICAL MONITORING FOR FIT
AND ACCLIMATIZED WORKERS^{a/}

Adjusted Temperature ^{b/}	Normal Work Ensemble ^{c/}	Impermeable Ensemble ^{d/}
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5° - 90°F (30.8° - 32.2° C)	After each 60 minutes of work	After each 30 minutes of work
82.5° -87.5° F (28.1° - 30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5° F (25.3° - 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5° - 25.3°C)	After each 150 minutes of work	After each 120 minutes of work

^{a/} For work levels of 250 kilocalories/per hour.

^{b/} Calculate the adjusted air temperature (ta adj) by using this equation: $ta\ adj = ta\ ^\circ F + (13 \times \text{sunshine multiplier})$ [i.e., 50 percent sunshine equals a .5 multiplier). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate the sunshine multiplier by judging what percent of time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine - no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows).

^{c/} A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and trousers.

^{d/} Saranex[®], Poly-Coated Tyvek[®], Etc.

- If oral temperature exceeds 99.6° (37.6°C), the next work cycle will be reduced by one-third without changing the rest period.
- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, the following work cycle will be reduced by one-third.
- No worker will be permitted to wear a semipermeable or impermeable garment when oral temperature exceeds 100.6°F (38.1°C).

5.2.11 Cold Exposure

It is possible that work on this project may be conducted during the winter months; therefore, injury due to cold exposure may become a problem for field personnel. Cold exposure symptoms, including hypothermia and frostbite, will be monitored when personnel are exposed to low temperatures for extended periods of time.

Persons working outdoors in temperatures at or below freezing may suffer from cold exposure. During prolonged outdoor periods with inadequate clothing, effects of cold exposure may even occur at temperatures well above freezing. Cold exposure may cause severe injury by freezing exposed body surfaces (frostbite), or may result in profound generalized cooling (hypothermia), possibly causing death. Areas of the body which have high surface area-to-volume ratios such as fingers, toes, and ears are the most susceptible to frostbite.

Two factors influence the development of a cold injury: ambient temperature and wind velocity. Wind chill is used to describe the chilling effect of moving air in combination with low temperature. For example, 14°F with a wind speed of 15 miles per hour (mph) is equivalent in chilling effect to still air at -18°F. Cold exposure is particularly a threat to site workers if the body cools suddenly when chemical-protective equipment is removed, and the clothing underneath is perspiration-soaked. The presence of wind greatly increases the rate of cooling.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- Frost nip or incipient frostbite: characterized by suddenly blanching or whitening of skin.
- Superficial frostbite: skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- Deep frostbite: tissues are cold, pale, and solid; an extremely serious injury.

Systemic hypothermia, or lowering of the core body temperature, is caused by exposure to freezing or rapidly dropping temperatures. Symptoms are usually exhibited in five stages:

- Shivering and uncoordination;
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F (35°C);
- Unconsciousness, glassy stare, slow pulse, and slow respiratory rate;
- Freezing of the extremities; and
- Death.

5.2.11.1 Evaluation and Control

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 5.3. For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C (-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.3°F) regardless of wind speed.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents. If fine work is to be performed with bare hands for more than 10 to 20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be used. At temperatures below -1°C (30.2°F), metal handles of tools and control bars should be covered by thermal insulating material.

TABLE 5.3
THRESHOLD LIMIT VALUES WORK/
WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT

Air Temperature - Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx.)	°F (approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm. Breaks)	1	(Norm. Breaks)	1	75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24°	(Norm. Breaks)	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency	
-35° to -37°	-30° to -34°	55 min	3	40 min	4	30 min	5	Non-emergency		work should cease	
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Non-emergency		work should cease			
-40° to -42°	-40° to -44°	30 min	5	Non-emergency		work should cease					
-43° & below	-45° & below	Non-emergency work should cease		work should cease							
				↓		↓		↓		↓	

Notes for Table 5.3

- Schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods in a warm location and with an extended break (e.g., lunch) at the end of the 4-hour work period in a warm location. For light-to-moderate work (limited physical movement): apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4 hour period (Step 5).
- The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
- In general the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.
- TLVs apply only for workers in dry clothing.

To prevent contact frostbite, workers should wear gloves. When cold surfaces below -7°C (19.4°F) are within reach, a warning will be given to the workers by the supervisor or SHSO to prevent inadvertent contact with bare skin. If the air temperature is -17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers will wear cold protective clothing appropriate for the level of cold and physical activity. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work will be modified or suspended until adequate clothing is made available or until weather conditions improve.

5.2.11.2 Work-Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) below -7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms) will be made available nearby. The workers will be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation, or a change of dry work clothing should be provided. A change of dry work clothing may be necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid

volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

- The workers will be under constant protective observation (buddy system or supervision).
- The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods will be taken in unheated shelters, and the opportunity for changing into dry clothing should be provided.
- New employees should not be required to work full-time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.
- The weight and bulkiness of clothing should be included in estimating the required work performances and weights to be lifted by the worker.
- The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats will not be used. The worker should be protected from drafts to the greatest extent possible.
- The workers will be instructed in safety and health procedures relative to cold exposures.

5.3 BIOLOGICAL HAZARDS

Various biological hazards may be encountered at the installations. These hazards include pathogenic organisms or diseases such as Hantavirus, Bubonic Plague, Equine Encephalitis, and Lyme Disease. Other biological hazards include insects, snakes, spiders, and cactuses or other harmful plants (such as poison ivy).

Hantavirus has been reported from the “Four Corners” area of the southwestern U.S. The Four Corners strain of Hantavirus has had a 60 percent mortality rate. Deer mice are the primary reservoir for the virus. The virus is excreted in mouse feces, urine, and saliva. People become infected when the virus is inhaled, through breaks in the skin, by ingesting contaminated food or water, or by being bitten by an infected rodent.

The incubation period for Hantavirus may be three days to six weeks. Symptoms include fever, chills, headache, dizziness, muscle aches, dry cough, nausea, vomiting, abdominal cramps, diarrhea, and shortness of breath. Progression of the disease leads to fluid in the lungs, heart irregularities, and kidney failure. Personnel will use HEPA-equipped air-purifying respirators when working in rodent-infested areas or when entering sheds of buildings containing mice infestations.

Bubonic plague is a bacterial disease which is spread to humans by fleas that have bitten an infected animal. Bubonic plague displays symptoms rapidly. Chills and fever are soon accompanied by swelling of the lymph nodes, usually on one side of the body. These painful swellings are usually dark blue to black, hence the other common name for this disease, “black death.” The disease is treatable with antibiotics. Field personnel must wear Tyvek® suits with leg seams taped to boots or boot covers to minimize contact with fleas while working in prairie dog towns.

Equine encephalitis, an inflammation of the brain, can be carried by mosquitoes. Field personnel must wear long-sleeved clothing and/or use insect repellents if they are working in areas of mosquito infestations.

Bites from wood ticks may result in the transmission of Lyme disease - a serious and often fatal bacterial disease. The *Borrelia burgdorferi* bacteria infects wood ticks, which can bite humans and transfer the bacteria into the bloodstream. Transmission of Lyme disease is most likely in late spring, summer, and early fall.

There are three stages of Lyme disease, although not everyone will proceed through all the stages or experience all the symptoms. The initial symptoms may include a red rash

that is circular and blotchy and expands around the tick bite, and flu-like symptoms such as fatigue, headaches, fever, swollen glands, and stiffness and pain in muscles and joints. The next stage can occur from a few days to a few weeks after the initial stage. Symptoms of this phase may include irregular heartbeat, facial paralysis, joint pain, irritability, headaches, dizziness, poor coordination, weakness, severe fatigue, and memory loss. The third stage may occur weeks to years after the second stage. Arthritis, often in the knees, is the most common symptom of this stage. The arthritis may disappear and recur many times, and chronic arthritis may develop.

Prompt medical treatment with antibiotics is usually successful in preventing further complications from this disease. Lyme disease becomes more difficult to treat the longer treatment is delayed. Long-sleeved shirts with snug collar and cuffs, pants tucked into socks, and personal protective equipment will offer some protection. However, the use of tick repellent may also be warranted. Personnel should perform self-checks for ticks at the end of each work day.

The potential exists for contact with snakes or insects which may cause injury or disease when performing investigation or remediation activities at the installations. There are plants which may be injurious (i.e., thorns) as well. Sturdy work clothes and shoes will be worn by field personnel to help prevent injuries. Personnel should be aware that rattlesnakes, water moccasins or alligators may be present in an area and should therefore exercise caution, especially when working in previously undisturbed areas and locations around animal dens and wetland habitats.

Poison ivy, poison oak, and poison sumac can be encountered at many installations. Poison ivy is a woody vine leaves are divided into three leaflets. Poison oak is a low branching shrub with leaflets also in threes. Poison sumac is a shrub or small tree occurring in swamps. Poison sumac have 7 to 13 leaflets which resemble those of green ash trees. All of these species are poisonous and can cause contact dermatitis. Personnel must wear Tyvek® suits or other protective clothing when working in areas containing these plant species.

Black widow spiders and scorpions may also be present onsite. The black widow spider has a shiny black body about the size of a pea, with a red or yellow hourglass-shaped mark on its abdomen. It weaves shapeless diffuse webs in undisturbed areas. A bite may result in severe pain, illness, and possible death from complications, but usually not from the bite itself. There are several types of scorpions native to the United States. Scorpions may be brown to yellowish in color, and range from 1/2 inch to 8 inches in length. Their bodies are divided into two parts: a short, thick upper body, and a long abdomen with a six-segment tail. A scorpion has six pairs of jointed appendages: one pair of small pincers, one pair of large claws, and four pairs of jointed legs. They are most active at night. A scorpion sting is very painful, but usually will not result in death.

In addition to spiders and scorpions, bees and wasps may be nuisances to field personnel. Properly trained personnel will administer first aid should a bee or wasp sting occur.

SECTION 6

EMERGENCY RESPONSE PLAN

All hazardous waste site activities will present a degree of risk to onsite personnel. During routine operations, risk is minimized by establishing good work practices, staying alert, and using proper PPE. Unpredictable events such as physical injury, chemical exposure, or fire may occur and must be anticipated. The sections below establish procedures and guidelines for emergencies.

6.1 GUIDELINES FOR PRE-EMERGENCY PLANNING AND TRAINING

Employees must read this program health and safety plan and the appropriate site-specific addendum to this plan, and familiarize themselves with the information provided. Prior to project initiation, the SHSO will conduct a meeting with the field team members to review the provisions of this program health and safety plan and the addendum, and to review the emergency response plan. Employees are required to have a copy of the emergency contacts and telephone numbers immediately accessible onsite and know the route to the nearest emergency medical services. The emergency contacts, telephone numbers, and routes to the hospital will be provided in the site-specific health and safety plan addendum prepared for each site. Appendix A provides a guideline for preparing this information.

6.2 EMERGENCY RECOGNITION AND PREVENTION

Emergency conditions are considered to exist if:

- Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while onsite.

- A condition is discovered that suggests the existence of a situation more hazardous than anticipated (e.g. flammable atmospheres).
- Concentrations of combustible vapors reach or exceed 10 percent of the lower explosive limit (LEL).
- A fire or explosion hazard exists.
- Concentrations of organic vapors measured in the worker breathing zone by a photoionization detector (PID) are above background air concentrations greater than an amount equal to the lowest permissible exposure limit (PEL) of a contaminant of concern onsite.
- A vehicle accident occurs.

Preventive measures are listed below.

- Site workers must maintain visual contact and should remain close together to assist each other during emergencies. (Use the buddy system.)
- During continual operations, onsite workers act as safety backup to each other. Offsite personnel provide emergency assistance.
- All field crew members should make use of all of their senses to alert themselves to potentially dangerous situations to avoid (e.g., presence of strong and irritating or nauseating odors).
- Personnel will practice unfamiliar operations prior to performing them in the field.
- Field crew members will be familiar with the physical characteristics of investigations and field demonstrations, including:
 - Wind direction in relation to contamination zones;
 - Accessibility to co-workers, equipment, vehicles and communication devices;

- Communication signals and devices;
 - Hot zone locations (areas of known or suspected contamination);
 - Site access; and
 - Nearest water sources.
- Personnel and equipment in the designated work area should be minimized, consistent with effective site operations.

The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated, will result in the reevaluation of the hazard and the level of protection required, and may result in a temporary evacuation of the field team from the immediate work area. Such conditions may include an adverse effect or symptom of exposure experienced by a field team member, or the exceedance of the action levels for organic vapors and/or combustible vapors. If the action levels for organic vapors and/or combustibles are exceeded, procedures will be followed as stated in Section 7 of this health and safety plan.

In the event of an accident, the SHSO or site manager will complete the Accident Report Form provided in Appendix B. Copies of the completed forms will be maintained by the program health and safety manager in the health and safety file of the affected employee. Follow-up action should be taken to correct the situation that caused the accident.

Near-miss incidents will also be documented using the form provided in Appendix B, and filed with the onsite health and safety records, as well as with the program health and safety manager. Near-miss incidents are defined as any incident which could have led to injury or property damage, but for whatever reason, did not. The assessment of near-miss incidents provides a better measure of safety program effectiveness than simply tracking accidents, since near-misses tend to occur at much higher frequencies than actual accidents.

6.3 PERSONNEL ROLES, LINES OF AUTHORITY, AND COMMUNICATION PROCEDURES DURING AN EMERGENCY

When an emergency occurs, decisive action is required. Rapidly made choices may have far-reaching, long-term consequences. Delays of minutes can create or exacerbate life-threatening situations. Personnel must be ready to respond to emergency situations immediately. All personnel will know their own responsibilities during an emergency, know who is in charge during an emergency, and the extent of that person's authority. This section outlines personnel roles, lines of authority, and communication procedures during emergencies.

In the event of an emergency situation at the site, the site manager will assume total control and will be responsible for onsite decision-making. The designated alternate for the site manager will be the SHSO. These individuals have the authority to resolve all disputes about health and safety requirements and precautions. They will also be responsible for coordinating all activities until emergency response teams (ambulance, fire department, etc.) arrive onsite.

The site manager and/or SHSO will ensure that the necessary Army personnel, Parsons ES personnel, and agencies are contacted as soon as possible after the emergency occurs. All onsite personnel must know the location of the nearest phone and the location of the emergency phone number list.

6.4 EVACUATION ROUTES AND PROCEDURES, SAFE DISTANCES, AND PLACES OF REFUGE

In the event of emergency conditions, decontaminated employees will evacuate the area as instructed, transport decontaminated injured personnel, or take other measures to ameliorate the situation. Evacuation routes and safe distances will be decided upon and posted by the field team prior to initiating work. Evacuation routes will be oriented upwind of the exclusion zone. Wind direction will be monitored through the use of wind socks, surveyors flagging or other appropriate measures.

6.5 DECONTAMINATION OF PERSONNEL DURING AN EMERGENCY

Procedures for leaving a contaminated area must be planned and implemented prior to going onsite. Decontamination areas and procedures will be established based on anticipated site conditions. If a member of the field crew is exposed to chemicals, the emergency procedures outlined below will be followed:

- Another team member (buddy) will assist or remove the individual from the immediate area of contamination to an upwind location.
- Precautions will be taken to avoid exposure of other individuals to the chemical.
- If the chemical is on the individual's clothing, the clothing will be removed if it is safe to do so.
- Administer first aid and transport the victim to the nearest medical facility, if necessary.

If uninjured employees are required to evacuate a contaminated area in an emergency situation, emergency decontamination procedures will be followed. At a minimum, these would involve moving into a safe area and removing protective equipment. Care will be taken to minimize contamination of the safe area and personnel. Contaminated clothing will be placed in plastic garbage bags or other suitable containers. Employees will wash or shower as soon as possible.

6.6 EMERGENCY SITE SECURITY AND CONTROL

For this project, the site manager (or designated representative) must know who is onsite and who is in the work area. Personnel access into the work area will be controlled. In an emergency situation, only necessary rescue and response personnel will be allowed into the exclusion zone.

6.7 PROCEDURES FOR EMERGENCY MEDICAL TREATMENT AND FIRST AID

The following general procedures will be implemented in the event of an emergency. Site-specific addenda will incorporate specific emergency procedures, emergency contact names and telephone numbers and a map detailing the route to the local hospital.

6.7.1 Chemical Exposure

In the event of chemical exposure (skin contact, inhalation, ingestion) the following procedures will be implemented:

- Another team member (buddy) will assist or remove the individual from the immediate area of contamination to an upwind location.
- Precautions will be taken to avoid exposure of other individuals to the chemical.
- If the chemical is on the individual's clothing, the clothing will be removed if it is safe to do so.
- If the chemical has contacted the skin, the skin will be washed with copious amounts of water, preferably under a shower.
- In case of eye contact, an emergency eyewash will be used. Eyes will be washed for at least 15 minutes. Emergency eyewashes will comply with ANSI Z-358.1 and filled with tempered water maintained no cooler than 60°F and no warmer than 95°F. Eyewashes will be capable of delivering 0.4 to 0.8 gallons of water to both eyes for a minimum of 15 minutes. Each jobsite will have at least one emergency eyewash station. Each crew will have, at a minimum, an ANSI-approved personal eyewash suitable for initial eye flushing while the injured person is moved to an emergency eyewash station or medical facility.
- If necessary, the victim will be transported to the nearest hospital or medical center. If necessary, an ambulance will be called to transport the victim.

6.7.2 Personal Injury

In the event of personal injury:

- Field team members trained in first aid can administer treatment to an injured worker.
- The victim will be transported to the nearest hospital or medical center. If necessary, an ambulance will be called to transport the victim.
- The SHSO or site manager is responsible for the completion of the appropriate accident report form.

6.7.3 Fire or Explosion

In the event of fire or explosion, personnel will evacuate the area immediately. Administer necessary first aid to injured employees. Personnel will proceed to a safe area and telephone the emergency support services designated in the appropriate sit-specific addendum. Upon contacting the emergency support services, state your name, nature of the hazard (fire, high combustible vapor levels), the location of the incident, and whether there were any physical injuries requiring an ambulance. Do not hang up until the emergency support services personnel have all of the additional information they may require.

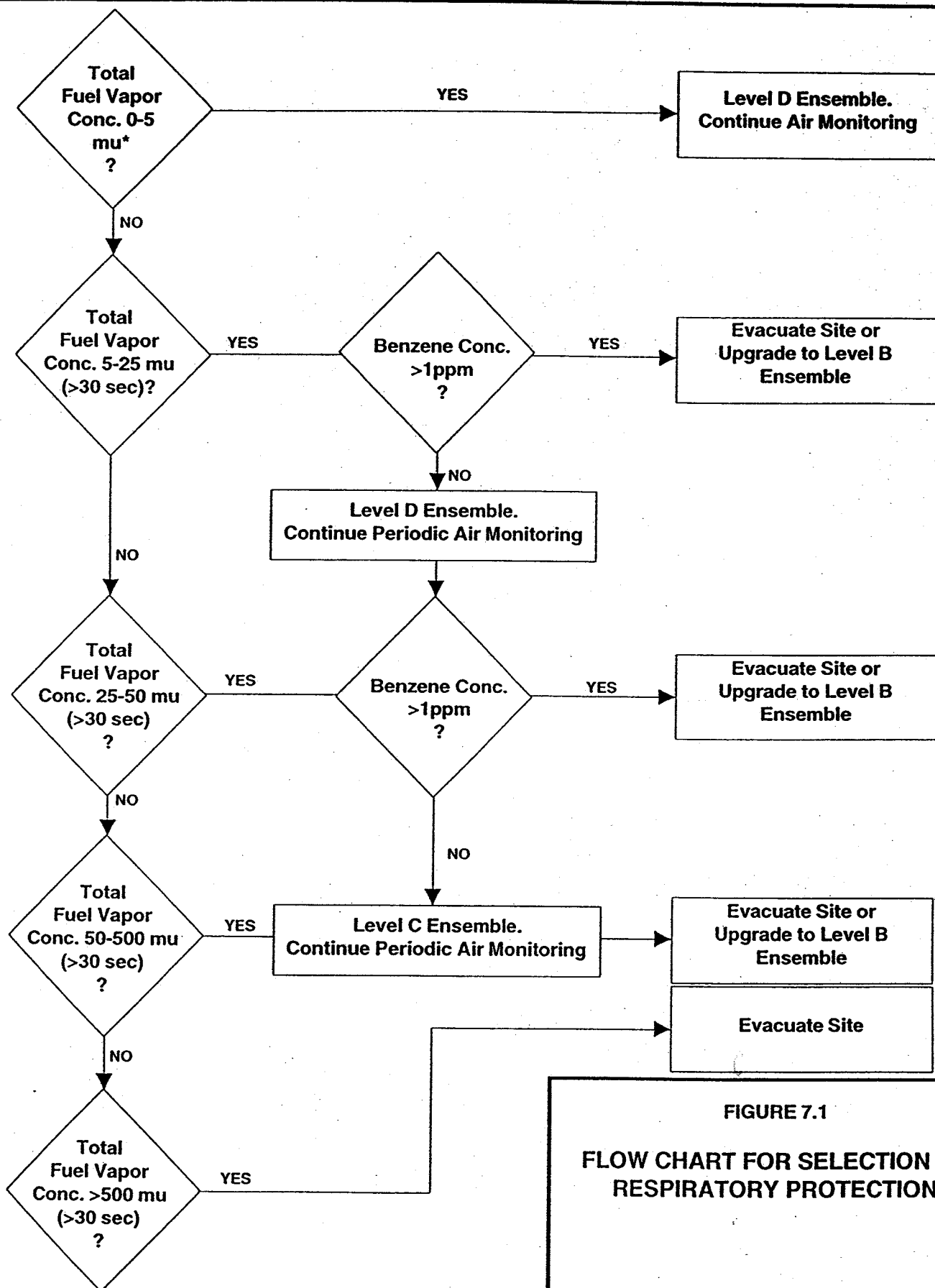
SECTION 7

LEVELS OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR SITE ACTIVITIES

7.1 PERSONAL PROTECTIVE EQUIPMENT

The personal protection level prescribed for the bioremediation treatability studies is OSHA Level D (no respiratory or chemical protective clothing), with a contingency for the use of OSHA Level C or B as site conditions require (Figure 7.1). Unless certain compounds are ruled out through use of appropriate air monitoring techniques such as Dräger[®] tubes, portable sampling pumps, or an onsite gas chromatograph (GC), Level C respiratory protection (air-purifying respirator [APR]) cannot be used. Level C protection may only be used on this project when vapors in air are adequately identified and quantified and Level C respirator-use criteria are met. Level B (supplied air) respiratory protection must be used on this project in the presence of unknown vapor constituents or if benzene or vinyl chloride is detected at or above 1 part per million, volume per volume (ppmv). This is based primarily on the toxicity and inadequate warning properties (high odor threshold) for benzene and vinyl chloride. In addition, the PEL for 1,1-DCE is also 1 ppmv. The presence of 1,1-DCE can only be confirmed by laboratory analysis. Air monitoring must be conducted in the worker breathing zone when the potential occurrence of these compounds exists.

Ambient air monitoring of organic gases/vapors (using photoionization detectors such as an HNU[®] or Photovac[®] MicroTIP[®], or by colorimetric analysis with Dräger[®] tubes) will be used to select the appropriate level of personal protection. If there is the potential for vinyl chloride at the site, a reading of 1 ppmv or greater above background in the worker breathing zone as indicated by a PID will require the use of a Dräger[®] tube or the equivalent to determine if vinyl chloride is present at a concentration greater than or equal



* mu = Meter Units



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**FIGURE 7.1
FLOW CHART FOR SELECTION OF
RESPIRATORY PROTECTION**

to the PEL of 1 ppmv. Due to the inadequate warning properties of vinyl chloride, Level B protection must be used if concentrations of vinyl chloride exceed 1 ppmv above background in the worker breathing zone. If vinyl chloride is not present, continue to monitor the air in the worker breathing zone. If concentrations in the worker breathing zone persist above 1 ppmv as indicated by the PID, periodic use of the vinyl chloride Dräger® tubes must be used to confirm the absence of vinyl chloride.

If there exists the potential for 1,1-DCE at the site, the following will occur since there is no Dräger® tube for 1,1-DCE. If sustained air monitoring readings in the worker breathing zone indicate vapor concentrations greater than or equal to 1 ppm above background for 30 seconds or longer, the field crew will be forced to evacuate and ventilate the area until readings are less than 1 ppm in the worker breathing zone. If ventilation is inadequate, air samples will be taken to confirm or deny the existence of the contaminants of concern and/or the crew will upgrade to Level B respiratory protection. These samples will be sent to a lab to analyzed by Environmental Protection Agency (EPA) Compendium Method TO-14 or the equivalent.

If the aforementioned solvents are not present, the flow chart presented in Figure 7.1 will be used to select respiratory protection against volatile hydrocarbon constituents. If the portable air monitoring equipment indicates organic vapor concentrations of 0-5 meter units (mu), site workers will continue air monitoring in a Level D ensemble. If organic vapors reach 5-25 mu for more than 30 seconds, and benzene concentrations exceed 1 ppmv, site workers will evacuate the area or upgrade to Level B ensemble, if trained to do so. If benzene concentrations are less than 1 ppmv in the breathing zone, and vapors are in the range of 5-25 mu, the site crews may continue in Level D ensembles with periodic air monitoring. If organic vapor concentrations reach 25-50 mu for more than 30 seconds and benzene concentrations exceed 1 ppmv in the worker breathing zone, site crews will evacuate the area or upgrade to Level B ensembles. If benzene concentrations are less than 1 ppmv, and vapors are in the range of 25-50 mu, site workers will don full facepiece APRs equipped with organic vapor cartridges (National Institute for Occupational Safety

and Health [NIOSH]-approved), and continue periodic monitoring. If organic vapor concentrations reach 50-500 mu for more than 30 seconds, site crews will evacuate the site or upgrade to Level B ensembles. If organic vapor concentrations exceed 500 mu for more than 30 seconds, site crews will evacuate the site.

Before work can be performed in Level B respiratory protection, the project manager must be notified. He will initiate the change order process with the Army or decide to halt activities at that site. (Level B operations also require approval from Parsons ES corporate health and safety.) The SHSO will determine whether it is safe to continue activities without respiratory protection or assign an upgrade to Level C protection.

The use of PPE will be required when handling contaminated samples and working with potentially contaminated materials. The SHSO must ensure that all field personnel are properly trained in use, maintenance, limitations (including breakthrough time), and disposal of PPE assigned to them, in accordance with federal OSHA regulations in 29 CFR 1910.132. Disposable PPE will be used whenever possible to simplify decontamination, to reduce generation of contaminated washwater, and to avoid potential problems with chemical permeation (breakthrough). Single-use PPE (such as Tyvek®) will be disposed of whenever personnel go through decontamination. At most, a single item of disposable PPE (including respirator cartridges) will be used for no more than one day and will then be disposed of. Double layers of gloves will be used when personnel are handling contaminated soil or water, or equipment to minimize breakthrough. If personnel note chemical odors on their hands, clothing or skin after wearing PPE, or develop skin irritation or rashes, consult with the SHSO and decide on alternate actions and/or seek medical attention.

Respirator and other PPE selection will be determined for each of the sites individually and variations from what is specified in this plan will be presented in the site-specific addenda. The criteria will be based on previously collected data indicating the contaminants of concern and their concentrations. Respiratory protection against chlorinated solvents will be discussed in the site-specific addenda. Hard hats will be

worn in the vicinity of the auger drilling rig and Geoprobe® unit and in all other areas where a head impact hazard exists. Steel-toed, steel-shank leather workboots will be worn by all field personnel.

The following personal protective ensemble is required only when handling contaminated samples or equipment.

<u>Mandatory Equipment</u>	<u>Optional Equipment</u>
<ul style="list-style-type: none">• Vinyl or latex inner gloves• 4H or SilverShield® outer gloves	<ul style="list-style-type: none">• Air-purifying respirator (equipped with organic vapor/high-efficiency particulate air [HEPA] cartridges)• Self-contained breathing apparatus or air-line respirator in pressure-demand mode• Rubber safety boots• Disposable Tyvek® coveralls• Outer disposable boot covers• Saranex® suits• Chemical goggles

7.2 EQUIPMENT NEEDS

Each field team will have the following items readily available:

- Copy of this program health and safety plan, site-specific addendum, and a separate list of emergency contacts;
- First aid kit which includes PPE for bloodborne pathogens;
- Eyewash station;
- Paper towels;

- Duct tape;
- Water (for drinking and washing);
- Plastic garbage bags;
- Fire extinguisher; and
- Earplugs.

7.3 EQUIPMENT DISPOSAL

All reusable PPE (such as hard hats and respirators), if contaminated, will be decontaminated in accordance with procedures specified in Section 10 of this health and safety plan. Contaminated single-use PPE (such as Tyvek® suits and protective gloves) will be properly disposed of according to installation requirements.

SECTION 8

FREQUENCY AND TYPES OF AIR MONITORING

Air monitoring will be used to identify and quantify airborne levels of hazardous substances. Periodic monitoring is required during on site activities. The types of monitoring and equipment to be used are as follows:

<u>Type of Equipment</u>	<u>Minimum Calibration Frequency</u>	<u>Parameter(s) to be Measured</u>	<u>Minimum Sampling Frequency</u>	<u>Sampling Locations</u>
Photoionization Detector	1/day	Benzene Organic Vapors	2/hour for general site activities	Breathing Zone
Explosivity Meter	1/day	Combustible Gases	2/hour	Soil Borings Monitoring Wells
Sensidyne® or Drager® Tubes	None (check manufacturer's requirements)	Benzene Organic Vapors	When PID exceeds lowest PEL of the contaminants of concern	Breathing Zone
Dosimeter Badges	None	Benzene Organic Vapors	As needed on workers with greatest exposure to contamination initially detected by Drager® tubes	Breathing Zone
Portable Air Sampling Pumps	Prior to and after each use	Benzene Organic Vapors	As needed on workers with greatest exposure to contamination initially detected by Drager® tubes	Breathing Zone

During bioremediation activities, a photoionization detector (such as an HNU® or MicroTIP®) will be used to measure ambient air concentrations in the worker breathing

zone. The size of the PID lamp will be determined for each site individually, based on the ionization potential of the contaminants. This information will be presented in the site-specific addenda.

Evacuation may be necessary if the lowest PEL of a contaminant of concern is exceeded above background in the breathing zone of the site workers. This evacuation will be necessary until the area is well ventilated or the respiratory protection is upgraded, if possible. Any detectable concentration above background concentrations in the breathing zone will necessitate following the respiratory protection flowchart (Figure 7.1). The explosivity meter will be used at least twice per hour to measure combustible gas levels at the wellhead or borehole when a potential exists for combustible vapors. At 10 percent of the LEL, evacuate the area and allow the borehole to ventilate.

Worker exposure monitoring will be conducted to document any exposures of Parsons ES site personnel to organic vapors. Portable air sampling pumps or dosimeter badges will be used for personal exposure monitoring, if necessary. The following general protocols will be followed if badges or pumps are used.

Passive Dosimeter Badges

An organic vapor monitoring badge will be attached in the worker's breathing zone for an eight-hour period when the potential for exposure exists. The exposed badges and a blank will be sent to the laboratory for analysis. These personal dosimeter badges work by means of diffusion eliminating the need for a pump, calibration or batteries.

Portable Sampling Pumps

- The portable pump will be calibrated to the required flow rate (in liters per minute) following the manufacturer's calibration procedures.
- The pump will be equipped with the appropriate sorbent tube for the particular organic compounds to be monitored (e.g., charcoal for volatile organics).

- A personal air monitoring data sheet (provided in Appendix B) listing pump flow rates, start and stop times, sorbent tube used, etc. will be completed.
- The pump will undergo a post calibration to determine final flow rates.
- The laboratory analytical results will be disclosed to the employee(s) monitored.
- The analytical results will be placed in the employee's permanent medical file for documentation of any exposures received.

SECTION 9

SITE CONTROL MEASURES

The following site control measures will be followed to minimize potential contamination of workers, protect the public from potential site hazards, and control access to the sites. Site control involves the physical arrangement and control of the operation zones and the methods for removing contaminants from workers and equipment. The first aspect, site organization, is discussed in this section. The second aspect, decontamination, is considered in the next section.

9.1 SITE ORGANIZATION-OPERATION ZONES

The following organization-operation zones will be established on the site or around a particular site feature (e.g., the drill rig).

- Exclusion Zone (Contamination Zone),
- Contamination Reduction Zone, and
- Support Zone.

The site manager and/or SHSO will be responsible for establishing the size and distance between zones at the site or around the site feature. Considerable judgment is required to ensure safe working distances for each zone are balanced against practical work considerations.

9.1.1 Exclusion Zone (Contamination Zone)

The exclusion zone includes the areas where active investigation or cleanup operations take place. Within the exclusion zone, prescribed levels of PPE must be worn by all

personnel. The hotline, or exclusion zone boundary, is initially established based upon the presence of actual wastes or apparent spilled material, or through air monitoring, and is placed around all physical indicators of hazardous substances. For drilling operations, the hotline will be located at a distance equal to the drilling rig boom height or 25 feet, whichever is greater, from the drill rig. The hotline generally consists of an easily identifiable physical boundary (e.g., bright orange or yellow flagging attached to stakes, and may be readjusted based upon subsequent observations and measurements. This boundary will be physically secured and posted or well-defined by physical and geographic boundaries.

Under some circumstances, the exclusion zone may be subdivided into zones based upon environmental measurements or expected onsite work conditions.

9.1.2 Contamination Reduction Zone

If decontamination is required, a contamination reduction zone will be established between the exclusion zone and the support zone. The contamination reduction zone will be located upwind of the exclusion zone. This zone provides an area to prevent or reduce the transfer of hazardous materials which may have been picked up by personnel or equipment leaving the exclusion area. All decontamination activities occur in this area. The organization of the contamination reduction zone, and the control of decontamination operations, are described in Section 10.

9.1.3 Support Zone

The support zone is the outermost area of the site and is considered a noncontaminated or clean area. The support zone contains the command post for field operations, first-aid stations, and other investigation and cleanup support. Normal work clothes are appropriate apparel within this zone; potentially contaminated personnel, clothing or equipment are not permitted.

9.2 SITE SECURITY

Site security is necessary to prevent exposure of unauthorized, unprotected individuals in the work area. The areas immediately surrounding the work area will be clearly marked through use of warning signs, traffic cones, barrier tape, rope, or other suitable means.

Site security will be enforced by the SHSO or a designated alternate who will ensure that only authorized personnel are allowed in the work area and that entry personnel have the required level of PPE, are trained under the requirements of 29 CFR 1910.120, and are on a current medical monitoring program.

9.3 SITE COMMUNICATION

Internal site communication is necessary to alert field team members in the exclusion and contamination reduction zones to:

- Emergency conditions;
- To convey safety information; and
- Communicate changes or clarification in the work to be performed.

For internal site communication, the field team members will use prearranged hand signals (and responses). Radios and/or compressed air horns may also be used for communication.

External site communication is necessary to coordinate emergency response teams and to maintain contact with essential offsite personnel. A telephone will be available for use in external site communication. A list of emergency contact telephone numbers will be provided in subsequent addenda.

9.4 SAFE WORK PRACTICES

To ensure a strong safety-awareness program during field operations, field personnel will be adequately trained for their particular tasks. In addition, standing work orders will

be developed and communicated to all field personnel, as will the provisions of this program health and safety plan and the appropriate addenda. Sample standing work orders for personnel entering the contamination reduction zone and exclusion zone are as follows:

- No horseplay at any time;
- No smoking, eating, drinking or chewing of tobacco or gum;
- Alcoholic beverage intake and illegal drug use is prohibited during the work shift and will result in immediate dismissal from the site;
- No matches or lighters;
- No personal vehicles;
- Check in/check out at access control points;
- Use the buddy system;
- Wear appropriate PPE;
- Avoid walking through puddles or stained soil;
- Upon discovery of unusual or unexpected conditions, immediately evacuate and reassess the site conditions and health and safety practices;
- Conduct safety briefings prior to onsite work;
- Conduct daily safety meetings; and
- Take precautions to reduce injuries resulting from heavy equipment and other tools.

SECTION 10

DECONTAMINATION PROCEDURES

10.1 PERSONNEL DECONTAMINATION PROCEDURES

An exclusion zone, contamination reduction zone, and support zone will be established whenever field personnel are using PPE. Decontamination station layout will be made on a site-specific basis and will be based on the level of PPE used, the types of chemical hazards encountered, and the site conditions, including topography, wind direction, and traffic patterns. Defined site access and egress points will be established and personnel will enter and exit only through these points. As a general rule, persons assisting in the decontamination station may be in one level lower of respiratory protection than required in the work zone.

A guideline for personnel decontamination is presented in Figure 10.1. This procedure may be modified by the SHSO if necessary.

If personnel are in Level D-modified protection (no respirator but using protective gloves and/or suits and other equipment), a portable decontamination station will be set up at the site. The decontamination station will include provisions for collecting disposable PPE (e.g., garbage bags); washing boots, gloves, vinyl rain suits, field instruments and tools; and washing hands, face, and other exposed body parts. Onsite personnel will shower at the end of the work day. Refuse from decontamination will be properly disposed of in accordance with US Air Force installation protocols.

Decontamination equipment will include:

- Plastic buckets and pails;

EXCLUSION ZONE

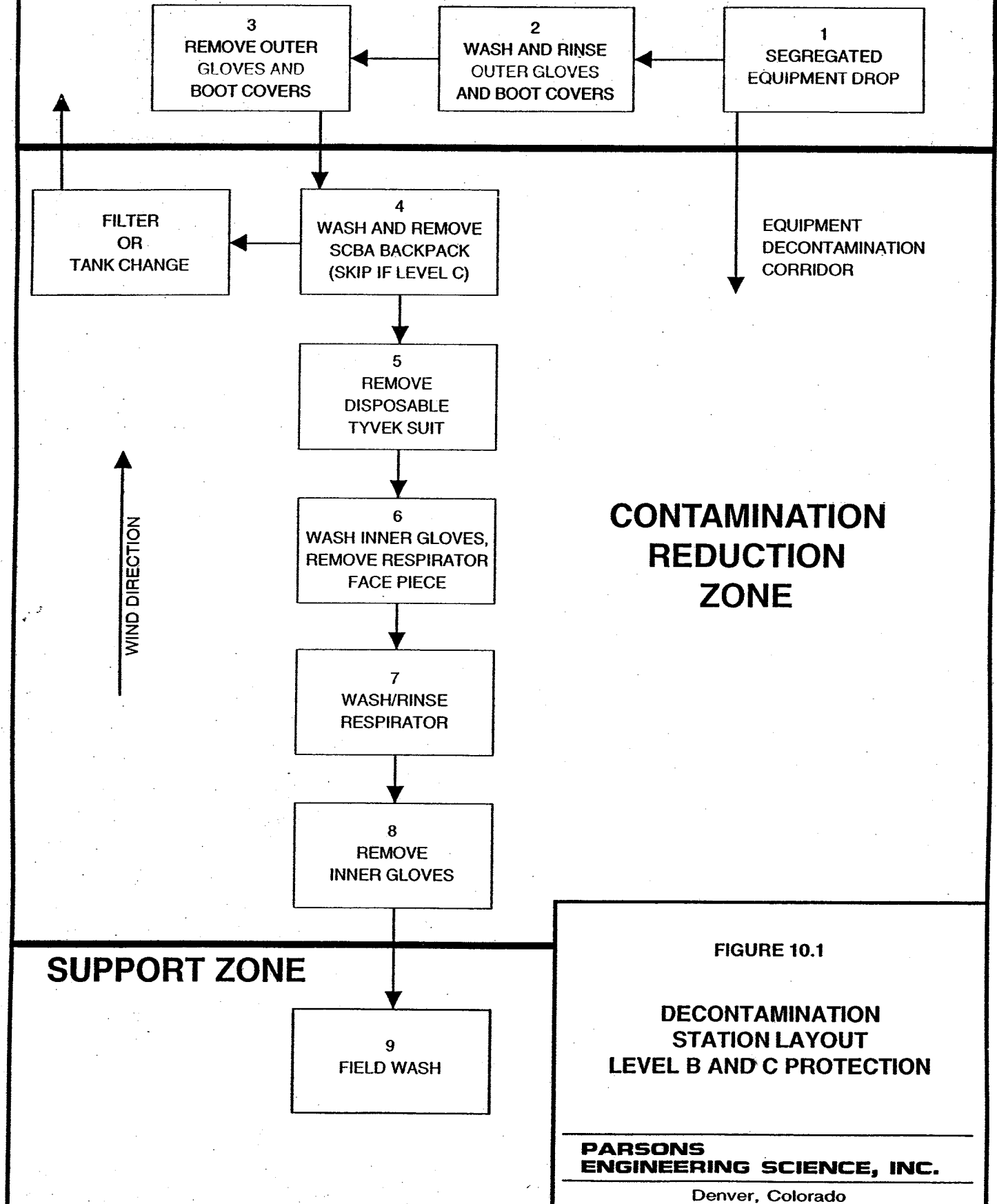


FIGURE 10.1

DECONTAMINATION
STATION LAYOUT
LEVEL B AND C PROTECTION

**PARSONS
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Denver, Colorado

- Scrub brushes and long-handle brushes;
- Detergent;
- Containers of water;
- Paper towels;
- Plastic garbage bags;
- Plastic or steel 55-gallon barrels;
- Distilled water; and
- An eyewash station.

10.2 DECONTAMINATION OF EQUIPMENT

Decontamination of drilling rigs will be conducted at a designated location. High-pressure steam-cleaning of the rig will be necessary prior to the beginning of the drilling operation, between borehole locations, and before the drilling rig leaves the project site. All sampling equipment will be decontaminated prior to use, between samples, and between sampling locations. PPE will consist of splash protective clothing, eye protection, gloves, and boot covers, as necessary.

SECTION 11

AIR MONITORING EQUIPMENT USE AND CALIBRATION PROCEDURES

11.1 PHOTOVAC MICROTIP® AIR ANALYZER

The MicroTIP® is a direct-reading instrument used in conjunction with the span gas kit. To calibrate the MicroTIP®, press the power switch. Allow the MicroTIP® to warm up; the display will read “Ready.” Press the calibration switch; the display will read “Connect zero gas then press enter.” Connect the bag of zero gas to the MicroTIP® inlet (or allow the MicroTIP® to sample clean air) and press enter; the display will read “Calibrating now please wait.” The display will then read "Span Conc.?" Enter the span concentration (usually 100 ppmv isobutylene). Connect the bag of span gas to the tip inlet and press enter; the display will read “Connect span gas then press enter.” The MicroTIP® will then calibrate. When the display reads “Ready,” the MicroTIP® has completed the calibration and is ready for use. Repeat the calibration daily.

To use the MicroTIP®, press the power switch and wait for the instrument to display the date, time, event number, current detected concentrations, and instrument status “ready.” The minimum, maximum, and average concentrations measured in each 15-second period are automatically recorded in memory. The keyboard also allows for direct numeric entry.

Since a calibration gas (i.e., isobutylene) is used which typically differs from the contaminants of concern, it may be necessary to combine the instrument reading with a response factor to more closely approximate the concentration of the contaminants of

concern. MSDSs for all chemicals (including calibration gases such as isobutylene) used in the field will be maintained by the field team.

Relative response factors are found in Table 11.1 for MicroTIP® models MP-100 and HL-200 with a 10.6 eV lamp. For these instruments, a more accurate concentration may be obtained by dividing the instrument reading by the appropriate relative response factor from Table 11.1 for the contaminant of concern.

For MicroTIP® instrument models MP-1000, HL-2000, IS-3000, and EX-4000 with a 10.6 eV lamp, the instrument reading is multiplied by the appropriate response factor from Table 11.2 for the contaminant of concern.

11.2 HNU® PHOTOIONIZATION DETECTOR

To calibrate the HNU®, turn the function switch to the “standby” mode and use the zero control to zero the instrument. Connect a bag of span gas (usually 100 ppmv isobutylene). Turn the function switch to the 0-200 range position and adjust the span control setting to read the ppmv concentration of the standard. Recheck the zero setting as previously described. If readjustment is needed, repeat the calibration step. This provides a two-point calibration to zero and the gas-standard point. Repeat the calibration daily. If the span setting from calibration is 0.0 or if calibration cannot be achieved, then the lamp must be cleaned.

To use the HNU® connect the probe to the instrument by matching the alignment slot in the probe connector to the key in the 12-pin connector on the control panel. Twist the probe connector until a distinct snap and lock is felt. Turn the function switch to battery check position. The needle should read within or above the green battery arc on the scale plate. If the needle is in the lower position of the battery arc, the instrument should be recharged before use. If the red light comes on, the battery should be recharged. Next, turn the functions switch to the on position, and the instrument is ready to take direct air readings.

TABLE 11.1
MICROTIP® RELATIVE RESPONSE FACTORS (10.6 eV LAMP)
INSTRUMENT MODELS MP-100 & HL-200

Compound	Relative Response Factor	Compound	Relative Response Factor
Acetaldehyde	0.17	Hydrogen Sulfide	0.25
Acetic Acid	0.09	Isobutyl Acetate	0.52
Acetone	0.86	Isobutyraldehyde	1.02
Acetone Cyanohydrin	0.93	Isopentane	0.12
Acrolein	0.28	Isoprene	2.12
Allyl Chloride	0.26	Isopropyl Acetate	0.43
Ammonia	0.10	Isopropyl Alcohol	0.23
Benzene	1.78	Methyl Bromide	0.45
1,3-Butadiene	1.43	Methyl tert-Butyl Ether	1.22
n-Butanol	0.27	Methyl Ethyl Ketone	1.10
see-Butanol	0.36	Methyl Isobutyl Ketone	0.87
n-Butyl Acetate	0.35	Methyl Mercaptan	1.60
n-Butyl Acrylate	0.53	Methyl Methacrylate	0.67
n-Butyl Mercaptan	1.36	Monoethylamine	1.25
n-Butylaldehyde	0.65	Monomethylamine	1.06
Carbon Disulfide	0.65	n-Octane	0.39
Chlorobenzene	2.24	n-Pentane	0.09
Cyclohexane	0.53	Perchloroethylene	1.40
Cyclohexanone	1.11	n-Propyl Acetate	0.31
1,2-Dichlorobenzene (ortho)	2.25	n-Propyl Alcohol	0.18
cis-1,2-Dichloroethylene	1.20	Propionaldehyde	0.56
trans-1,2-Dichloroethylene	2.21	Propylene	0.87
Diisobutylene	2.10	Propylene Oxide	0.13
1,4-Dioxane	0.83	Styrene	2.20
Epichlorohydrin	0.11	Tetrahydrofuran	0.65
Ethyl Alcohol	0.13	Toluene	1.91
Ethyl Acetate	0.25	Trichloroethylene	1.61
Ethyl Acrylate	0.30	Trimethylamine	1.35
Ethylene	0.09	Vinyl Acetate	0.84
Ethyl Mercaptan	1.82	Vinyl Bromide	2.24
Furfuryl Alcohol	1.43	Vinyl Chloride	0.51
n-Heptane	0.27	Vinylidene Chloride (1,1-DCE)	1.16
n-Hexane	0.20		

Note: Concentration = $\frac{\text{Instrument Reading}}{\text{Relative Response Factor}}$

TABLE 11.2
MICROTIP® RESPONSE FACTORS (10.6 eV LAMP)
INSTRUMENT MODELS MP-1000, HL-2000, IS-3000 & EX-4000

Compound	Response Factor	Compound	Response Factor
Acetaldehyde	6.6	n-Hexane	5.6
Acetic Acid	18.9	Hydrogen Sulfide	3.7
Acetone	1.2	Isobutyl Acetate	2.3
Acetone Cyanohydrin	1.2	Isobutyraldehyde	1.1
Acrolein	3.7	Isopentane	7.8
Allyl Chloride	4.3	Isoprene	0.6
Ammonia	10.1	Isopropyl Acetate	2.4
Benzene	0.6	Isopropyl Alcohol	4.5
1,3-Butadiene	0.7	Methyl Bromide	2.3
n-Butanol	4.6	Methyl tert-Butyl Ether	0.8
see-Butanol	3.0	Methyl Ethyl Ketone	0.9
n-Butyl Acetate	2.9	Methyl Isobutyl Ketone	1.1
n-Butyl Acrylate	1.9	Methyl Mercaptan	0.6
n-Butyl Mercaptan	0.7	Methyl Methacrylate	1.5
n-Butylaldehyde	1.9	Monoethylamine	0.8
Carbon Disulfide	1.4	Monomethylamine	1.0
Chlorobenzene	0.4	n-Octane	2.6
Cyclohexane	1.9	n-Pentane	10.8
Cyclohexanone	0.9	Perchloroethylene	0.7
1,2-Dichlorobenzene (ortho)	0.4	n-Propyl Acetate	3.5
cis-1,2-Dichloroethylene	0.8	n-Propyl Alcohol	6.3
trans-1,2-Dichloroethylene	0.4	Propionaldehyde	1.9
Diisobutylene	0.6	Propylene Oxide	7.1
Dimethylamine	1.5	Styrene	0.5
Di-n-propylamine	0.5	Tetrahydrofuran	1.5
1,4-Dioxane	1.2	Toluene	0.5
Epichlorohydrin	10.3	Trichloroethylene	0.6
Ethanol	11.1	Trimethylamine	0.9
Ethyl Acetate	4.2	Vinyl Acetate	1.2
Ethyl Acrylate	3.3	Vinyl Bromide	0.4
Ethylene	10.0	Vinyl Chloride	2.0
Ethyl Mercaptan	0.6	Vinylidene Chloride (1,1-DCE)	0.9
n-Heptane	3.7		

Note: Concentration = Instrument Reading x Response Factor

11.3 EXPLOSIVITY METER

An explosivity meter is used to measure oxygen and combustible gas levels. The instrument provides characteristic warning signals when deficient oxygen conditions or unacceptable levels of combustible gas are detected.

To use the explosivity meter, turn the unit on and wait a few seconds for the readings to stabilize. Check the battery charge and the alarms before using the instrument. Set the LEL indicator to zero and the oxygen indicator to 20.9 percent.

To calibrate the instrument, attach a bag, bulb or balloon of span gas and wait for the readings to stabilize. Adjust the instrument to read the LEL percent of the calibration gas. Remove the span gas and allow the instrument to exhaust. The combustible sensor will read 000-percent LEL in clean air.

11.4 SENSIDYNE® OR DRÄGER® COLORIMETRIC GAS ANALYSIS TUBES

Colorimetric tubes can be used to give an instantaneous reading of various organic compounds. Their aim is to determine very small concentrations of a compound in the shortest amount of time. To sample with a colorimetric tube use the Dräger® or Sensidyne® bellows pump and select the appropriate tube (for example, a tube marked benzene to look for benzene). Break off both ends on the pump's break-off plate. Insert the tube into the pump head (the tube should be inserted with the arrow pointing towards the pump). There is a specific number of suction strokes for each tube/compound. Each box of tubes will have instructions for how many suction strokes are required for that compound.

APPENDIX A

EMERGENCY CONTACTS

APPENDIX A

EMERGENCY CONTACTS

In the event of any situation or unplanned occurrence requiring assistance, the appropriate contact(s) should be made from a list similar to this which will be prepared in the health and safety plan addenda. For emergency situations, telephone or radio contact should be made with the site point of contact or site emergency personnel who will then contact the appropriate response teams.

Contingency Contacts

Telephone Number

Nearest phone located at the work site

Site Fire Department

Site Contact

Site Medical Services

Site Emergency Telephone Number

Site Security/Police

Medical Emergency

Hospital Name

Hospital Address

Hospital Telephone Number

Ambulance Service

Airlift Helicopter

Directions and/or Map to the Hospital

Parsons ES Contacts

Bruce Henry	(303) 831-8100 (w)
Project Manager	(303) 422-4019 (h)

Timothy Mustard, CIH (Denver)	(303) 831-8100 (w)
Program Health and Safety Manager	(303) 450-9778 (h)

Edward Grunwald, CIH (Atlanta)	(678) 969-2394 (w)
Corporate Health and Safety Manager	(404) 299-9970 (h)

Judy Blakemore (Denver)	(303) 831-8100 (w)
Assistant Program Health and Safety Manager	(303) 828-4028 (h)
	(303) 817-9734 (m)

USAEC Contacts

Patrick Haas, AFCEE	(210) 536-4314 (w)
Project Officer	

APPENDIX B

PROJECT HEALTH AND SAFETY FORMS

PLAN ACCEPTANCE FORM

PROJECT HEALTH AND SAFETY PLAN

Instructions: This form is to be completed by each person to work on the subject project work site and returned to the safety manager.

I have read and agree to abide by the contents of the Health and Safety Plan for the following project:

Signed

Date

RETURN TO:

Office Health and
Safety Representative
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, CO 80290

SITE SPECIFIC TRAINING RECORD

Project: _____
Project No.: _____
Date: _____
Trainer: _____

On this date, the following individuals were provided site-specific training in accordance with OSHA regulations contained in 29CFR1910.120(e):

<u>Name (Print)</u>	<u>Employee No.</u>	<u>Employee Signature</u>
---------------------	---------------------	---------------------------

Forward this form to:

Office Health and Safety Representative
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

PARSONS ENGINEERING SCIENCE, INC.

FIELD EXPERIENCE

DOCUMENTATION FORM

OSHA requires (29CFR1910.120(e)) that personnel involved in hazardous waste operations have 40-hours of initial training and a minimum of three days field experience working under the direction of a trained and experienced supervisor. This form serves to document the three days of additional field training/experience.

Employee Name: _____

Employee Number (or Social Security No.): _____

Project Name(s): _____

Project Number(s): _____

Dates of Field Training: _____

Summary of Activities Performed: _____

Levels of Respiratory Protection Used: _____

Comments:

Field Supervisor Signature: _____

Date: _____

Return this form to the Office Health and Safety Representative

PARSONS ENGINEERING SCIENCE, INC.
PERSONAL AIR MONITORING DATA FORM

PROJECT NAME _____

PROJECT NUMBER: _____

[illegible]

PID

Explosimeter

Other

Model _____

Model_____

Model _____

Serial # _____

Serial # _____

Serial # _____

Cal.* Gas _____

Cal Gas

Cal Gas

Cal. Reading _____

Cal. Reading_____

Cal. Reading_____

BG Reading

BG Reading_____

BG Reading_____

* Cal = Calibration

****BG = Background**

ENGINEERING-SCIENCE, INC.
AIR MONITORING DATA FORM

Date: _____

Project: _____

Name(s): _____

Project No.: _____

[illegible]

Project: _____

EMPLOYER

1. Name: _____
2. Mail Address: _____
(No. and Street) (City or Town) (State and Zip)
3. Location (if different from mail address): _____

INJURED OR ILL EMPLOYEE

4. Name: _____ Social Security No.: _____
(first) (middle) (last)
5. Home Address: _____
(No. and Street) (City or Town) (State and Zip)
6. Age: _____ 7. Sex: male () female ()
8. Occupation: _____
(specific job title, not the specific activity employee was performing at time of injury)
9. Department: _____
(enter name of department in which injured person is employed, even though they may have been temporarily working in another department at the time of injury)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident or exposure: _____
(No. and Street) (City or Town) (State and Zip)
11. Was place of accident or exposure on employer's premises? Yes () No ()
12. What was the employee doing when injured? _____
(be specific--was employee using tools or equipment
or handling material?)

13. How did the accident occur? _____
(describe fully the events that resulted in the injury or occupational illness.

Tell what happened and how. Name objects and substances involved. Give details on all factors that led to

accident. Use separate sheet for additional space).
14. Time of accident: _____

15. ES WITNESS TO ACCIDENT

_____	_____	_____
(Name)	(Affiliation)	(Phone No.)
_____	_____	_____
(Name)	(Affiliation)	(Phone No.)
_____	_____	_____
(Name)	(Affiliation)	(Phone No.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

16. Describe injury or illness in detail; indicate part of body affected:

17. Name the object or substance that directly injured the employee. (for example, object that struck employee; the vapor or poison inhaled or swallowed; the chemical or radiation that irritated the skin; or in cases of strains, hernias, etc., the object the employee was lifting, pulling, etc.).

18. Date of injury or initial diagnosis of occupational illness: _____
(date)

19. Did the accident result in employee fatality? Yes () No ()

20. Number of lost days ____/restricted workdays ____ resulting from injury or illness?

OTHER

21. Name and address of physician: _____
(No. and Street) (City or Town) (State and Zip)

22. If hospitalized, name and address: _____
(No. and Street) (City or Town) (State and Zip)

Date of report: _____ Prepared by: _____

Official position: _____

“NEAR MISS” INCIDENT INVESTIGATION REPORT FORM

- 1) Project name and number: _____
- 2) “Near miss” location: _____
- 3) Incident date and time: _____
- 4) Personnel present (optional): _____
- 5) Describe incident: _____

- 6) What action or condition contributed to incident? _____

- 7) What action was taken or suggested to prevent reoccurrence? _____

- 8) Comments _____

- 9) Date of report _____ Prepared by _____
- 10) Office health and safety representative review:

Signature

Date

**PARSONS ENGINEERING SCIENCE
SHIPPING PAPER**

Page 1 of

Parsons Engineering Science

(name of carrier)

Shipping Paper No.:

Date:

Consignee: <u> </u> Phone: <u> </u>		Shipper: <u> </u> Phone: <u> </u>	
Street: <u> </u>		Street: <u> </u>	
City: <u> </u>	State: <u> </u>	City: <u> </u>	State: <u> </u>
Zip: <u> </u>		Zip: <u> </u>	
Route <u> </u>		Vehicle License <u> </u>	
No. of Units and Packaging Type	HM	Basic Description (proper shipping name, hazard class, subsidiary risk, identification No. [UN], and packaging group)	Total Quantity (weight, volume, etc.)

PLACARDS TENDERED: yes ☐ no ☐

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

Name and Title of Shipper	Place and date
Emergency Telephone Number CHEM-TEL, 800/255-3924	Signature of Shipper

ATTACH MATERIAL SAFETY DATA SHEETS

PARSONS ENGINEERING SCIENCE, INC.
DAILY VEHICLE INSPECTION REPORT

☐ = OK

☒ = Adjustment Made

☐ R = Repair Needed

Date: _____

Time: _____

License Plate Number: _____

Vehicle Make and Type: _____

Rental Agency _____

General Vehicle Inspection:

- | | | | |
|---------------------|--------------------------|------------------------|--------------------------|
| 1. Windshield | <input type="checkbox"/> | 3. Vehicle Interior | <input type="checkbox"/> |
| 2. Vehicle Exterior | <input type="checkbox"/> | 4. Leaks under Vehicle | <input type="checkbox"/> |

Check that the following are in proper working order:

1. Lights:

- | | |
|--------------------|--------------------------|
| a. Headlights | <input type="checkbox"/> |
| b. Taillights | <input type="checkbox"/> |
| c. Turn Signals | <input type="checkbox"/> |
| d. Brake Lights | <input type="checkbox"/> |
| e. Back-up Lights | <input type="checkbox"/> |
| f. Interior Lights | <input type="checkbox"/> |

- | | |
|---|--------------------------|
| 2. Brakes | <input type="checkbox"/> |
| 3. Horn | <input type="checkbox"/> |
| 4. Tires properly inflated (refer to sticker on door or vehicle manual) | <input type="checkbox"/> |
| 5. Spare tire present and properly inflated | <input type="checkbox"/> |
| 6. Windshield wipers | <input type="checkbox"/> |
| 7. Windshield washers | <input type="checkbox"/> |
| 8. Defrosters/Defoggers | <input type="checkbox"/> |
| 9. Battery terminals free of corrosion | <input type="checkbox"/> |
| 10. Cooling system hoses | <input type="checkbox"/> |
| 11. Belts | <input type="checkbox"/> |

12. Fluid levels: (Circle approximate level)

- | | | |
|-----------------------|--------------------|-------------------|
| a. Oil: Full | 1 Quart low | Does not register |
| b. Coolant: Full cool | Needs some coolant | Does not register |
| c. Transmission: Full | 1 Pint low | Does not register |
- (NOTE: Check transmission fluid while vehicle is running!)
- | | | |
|----------|-----------------------------|--|
| d. Fuel: | E 1/4 1/2 3/4 F | |
|----------|-----------------------------|--|

Please note any problems, unusual conditions, repairs made or fluids added (except fuel):

LOG

DATES OF INVESTIGATION:

[illegible]

APR Performance Comments:

**Project H&S Officer
or
Parsons ES Project Manager**

Date _____

**Return to the Office Health and Safety Representative
at the Completion of field activities.**

LOG

DATES OF INVESTIGATION:

SAR Performance Comments:

Date _____

022/722426/7.WW6

LOG

DATE OF INVESTIGATION:

SCBA Performance Comments:

Date _____

022/722426/7.WW6

APPENDIX C

JOB SAFETY ANALYSES

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: General Health and Safety

Page 1 of 1

Potential Hazards	Recommended Controls
Slip, Trip, Fall, Loss of Balance	Site safety briefing Stay alert Maintain firm footing Use "buddy" system Watch for obstacles
Heat/Cold Stress	Wear appropriate clothing Monitor for heat/cold stress as recommended in the HASP Provide adequate drinking water (minimum 1.5 gallons/person) Carry communication equipment
Fire Hazards	Have approved fire protection devices available (see HASP) Equipment will be shut down prior to fueling Use good housekeeping procedures
Noise/Eye Hazards	Use hearing protection when appropriate Use approved safety glasses
Sharp Objects	Wear boots with steel toes and shanks Have a current tetanus booster as recommended by occupational physician Be extra cautious in areas containing medical "sharps"
Biohazard	Biohazard training Stay alert for snakes, insects, and animals Wear high-top safety boots
Physical Exertion	Follow work/rest regime Use "buddy" system Use proper lifting technique, size up the load, never twist or turn when lifting
Construction Hazards	Wear hard-hat, safety glasses, steel-toe/shank boots, and hearing protection when working near heavy equipment Never enter excavations Stay alert Maintain eye contact/communication with equipment operator when working in vicinity

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Geoprobe Operations

Page 1 of 2

Potential Hazards	Recommended Controls
Operations Hazards Faulty/Damaged Equipment Hand/Power tools Falling Objects Pinch/Contact Points Fire Hazards	Conduct utilities search prior to operation Wear hard-hat and steel-toe/shank boots and proper PPE (see HASP) Stay alert, watch for pinch/contact points (sliding platforms, rotary equipment, etc.) Never place hands on top of rod while it is under the machine Maintain eye contact/communication with equipment operator when working in vicinity Equipment will be operated by trained/experienced personnel only Equipment will be inspected upon arrival and at the beginning of each shift Take vehicle out of gear and set emergency brake before engaging the remote ignition Turn off the hydraulic system while changing rods, inserting the hammer anvil, or attaching accessories Stand to the control side of the machine, clear of the foot and mast Never exert down pressure on the probe rod so as to lift the machine base over 6 inches off the ground Keep feet and hands clear of moving/suspended materials and equipment Machine guards shall remain in place Carry fire extinguisher on board vehicle Be aware of locations of kill switches
Chemical Hazards	Conduct daily site safety briefing Conduct air monitoring as described in the HASP and use the appropriate PPE level Avoid contact with contaminated soil and groundwater Avoid breathing dust by using dust suppression, if necessary Be aware of possible exposure symptoms (e.g., headache, nausea, dizziness, sleepiness, etc.) Immediately report any exposure symptoms to the Site Health and Safety Officer
Physical Exertion	Follow work/rest regime Use "buddy" system Use proper lifting technique, size up the load, never twist or turn when lifting
Noise/Eye Hazards	Use hearing protection when appropriate Use approved safety glasses

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Geoprobe Operations

Page 2 of 2

Potential Hazards	Recommended Controls
Slip, Trip, Fall, Loss of Balance	Site safety briefing Stay alert Maintain firm footing Watch for obstacles Keep work area free of cords, cables, tools, equipment, etc., to prevent a tripping hazard
Biohazard	Biohazard training Stay alert for snakes, insects, and animals Wear high-top safety boots
Heat/Cold Stress	Wear appropriate clothing Monitor for heat/cold stress as recommended in the HASP Carry drinking water (minimum 1.5 gallons per person) Carry communication equipment
Fire Hazards	Have approved fire protection devices available (see HASP) Equipment will be shut down prior to fueling Use good housekeeping procedures
Sharps/Metal Fragments	Wear boots with steel toes and shanks Have a current tetanus booster as recommended by occupational physician

Equipment to be used	Inspection Requirements	Training Requirements
Communications Equipment Air Monitoring Instruments Drill Rig	Function Test: Communications Equipment Air Monitoring Instruments Inspect Drill Rig Daily	Site-specific training Biohazard training 40-hr OSHA hazardous waste operations training Read and comply with the HASP

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Drill Rig Operations

Page 1 of 2

Potential Hazards	Recommended Controls
Operations Hazards Faulty/Damaged Equipment Hand/Power tools Falling Objects Pinch/Contact Points Fire Hazards	Wear hardhat and steel-toe/shank boots and proper PPE (see HASP) Stay alert, watch for pinch/contact points (sliding platforms, rotary equipment, etc.) Maintain eye contact/communication with equipment operator when working in vicinity Equipment will be operated by trained/experienced personnel only Equipment will be inspected upon arrival and at the beginning of each shift (e.g., frayed cables, worn fittings, etc.) Equipment found to be unsafe will be tagged and locked out Keep feet and hands clear of moving/suspended materials and equipment Machine guards shall remain in place Use long-handled shovels to remove auger cuttings Carry fire extinguisher on board vehicle Be aware of locations of kill switches
Chemical Hazards	Conduct daily site safety briefing Conduct air monitoring as described in Section 8 of the HASP and use the appropriate PPE level Avoid contact with contaminated soil and groundwater Avoid breathing dust by using dust suppression, if necessary Be aware of possible exposure symptoms (e.g., headache, nausea, dizziness, sleepiness, etc.) Immediately report any exposure symptoms to the Site Health and Safety Officer
Physical Exertion	Follow work/rest regime Use "buddy" system Use proper lifting technique, size up the load, never twist or turn when lifting
Noise/Eye Protection	Use hearing protection when appropriate Use approved safety glasses
Slip, Trip, Fall, Loss of Balance	Site safety briefing Stay alert Maintain firm footing Watch for obstacles

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Drill Rig Operations

Page 2 of 2

Potential Hazards	Recommended Controls
Biohazard	Biohazard training Stay alert for snakes, insects, and animals Wear high-top safety boots
Heat/Cold Stress	Wear appropriate clothing Monitor for heat/cold stress as recommended in the HASP Carry drinking water (minimum 1.5 gallons per person) Carry communication equipment
Fire Hazards	Have approved fire protection devices available (see HASP) Equipment will be shut down prior to fueling Use good housekeeping procedures
Sharps/Metal Fragments	Wear boots with steel toes and shanks Have a current tetanus booster as recommended by occupational physician

Equipment to be used	Inspection Requirements	Training Requirements
Communications Equipment Air Monitoring Instruments Drill Rig	Function Test: Communications Equipment Air Monitoring Instruments Inspect Drill Rig Daily	Site-specific training Biohazard training 40-hr OSHA hazardous waste operations training Read and comply with the HASP

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Backhoe Operations

Page 1 of 2

Potential Hazards	Recommended Controls
Underground/Aboveground Utilities	Conduct utilities search prior to operations Mark utility locations for avoidance
Impact by Backhoe Arm (boom)	Fully extend bucket arm and define swing radius by inscribing an arc in the soil with the bucket or by delineating swing radius with traffic cones, barrier tape, or other suitable means No personnel will be allowed within swing radius during operations Personnel must establish eye contact with the operator and wait until the backhoe bucket is swung to one side and lowered to the ground, or the unit shut off, before entering the swing radius area.
Noise/Eye/Foot/Head Impact Hazards	Wear hearing protection when working near the backhoe Wear eye protection Wear hard hat Wear steel-toed, steel-shanked work boots
Excavation Cave-In	No person shall enter the excavation until it is properly sloped/shored and certified by a competent person Personnel must stay at least 3 feet away from sides and ends of trench. If workers must approach closer than 3 feet, they shall wear safety harness and be attached to a life line.
Chemical Hazards	Conduct daily site safety briefing Conduct air monitoring as described in the HASP and use the appropriate PPE level Avoid contact with contaminated soil and groundwater Avoid breathing dust by using dust suppression, if necessary Be aware of possible exposure symptoms (e.g., headache, nausea, dizziness, sleepiness, etc.) Immediately report any exposure symptoms to the Site Health and Safety Officer
Physical Exertion	Follow work/rest regime Use "buddy" system Use proper lifting technique, size up the load, never twist or turn when lifting

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Backhoe Operations

Page 2 of 2

Potential Hazards	Recommended Controls
Slip, Trip, Fall, Loss of Balance	Site safety briefing Stay alert Maintain firm footing Watch for obstacles Keep work area free of cords, cables, tools, equipment, etc., to prevent a tripping hazard
Biohazard	Biohazard training Stay alert for snakes, insects, and animals Wear high-top safety boots
Heat/Cold Stress	Wear appropriate clothing Monitor for heat/cold stress as recommended in the HASP Carry drinking water (minimum 1.5 gallons per person) Carry communication equipment
Fire Hazards	Have approved fire protection devices available (see HASP) Equipment will be shut down prior to fueling Use good housekeeping procedures

Equipment to be used	Inspection Requirements	Training Requirements
Communications Equipment Air Monitoring Instruments Backhoe	Function Test: Communications Equipment Air Monitoring Instruments Inspect backhoe Daily	Site-specific training Biohazard training 40-hr OSHA hazardous waste operations training Read and comply with the HASP

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: General Field Vehicle Operations

Page 1 of 1

Potential Hazards	Recommended Controls
Speeding	Observe posted speed limits Keep vehicle under control Operate at lesser speeds consistent with conditions
Backing up	Visual check around and behind vehicle Backup alarm or use observer to guide you Notify bystanders that vehicle is backing up (verbally or sound horn)
Unsafe Equipment	Perform vehicle inspection prior to shift Repair or replace defective equipment
Unfamiliar Area	Obtain map and/or detailed directions Lock doors
Unfamiliar Vehicle (e.g., rental car)	Familiarize yourself with controls Adjust seat, mirrors, etc. prior to putting vehicle in motion Set radio stations prior to putting vehicle in motion

PARSONS ENGINEERING SCIENCE, INC.
JOB SAFETY ANALYSIS

ACTIVITY: Concrete Coring/Chip Sampling

Page 1 of 1

Potential Hazards	Recommended Controls
Noise/Eye Hazards	Use hearing protection Use approved safety glasses
Electrical Hazards	Conduct utility clearance prior to coring to avoid electrical and other utilities Connect coring machine to ground-fault circuit interrupter (GFCI) Inspect power cords for defects; replace if necessary Wear rubber-soled boots
Physical Exertion	Follow work/rest regime Use "buddy" system Use proper lifting technique, size up the load, never turn or twist when lifting
Heat/Cold Stress	Wear appropriate clothing Monitor for heat/cold stress as recommended in the HASP Provide adequate drinking water (minimum 1.5 gallons/person)
Slip, Trip, Fall, Loss of Balance	Stay alert Keep electrical cords and water hoses out of way as much as possible Watch for obstacles Maintain firm footing Use "buddy" system
Pinch/Contact Points	Keep hands and feet clear of rotating machinery Wear steel-toed safety boots Wear leather gloves

APPENDIX B

SITE SPECIFIC HEALTH AND SAFETY PLAN ADDENDUM

**ADDENDUM TO THE
PROGRAM HEALTH AND SAFETY PLAN
FOR
TECHNOLOGY APPLICATION OF ORGANIC SUBSTRATE
ADDITION FOR ENHANCED IN SITU BIOREMEDIATION OF
HALOGENATED ALIPHATIC HYDROCARBONS**

AT

**NAVAL AIR STATION FORT WORTH
JOINT RESERVE BASE
(THE FORMER CARSWELL AIR FORCE BASE)
TEXAS**

May 2003

Prepared by:

PARSONS
1700 Broadway, Suite 900
Denver, Colorado 80290

REVIEWED AND APPROVED BY:

	Name	Date
Project Manager	<u>Brian M Henry</u>	<u>5/19/03</u>
Program Health & Safety Manager	<u>Timothy Stewart, CIH</u>	<u>5/19/03</u>

1.0 INTRODUCTION

This addendum modifies the existing program health and safety plan (HASP) entitled *Project Health and Safety Plan for Technology Application of Organic Substrate Addition for In Situ Enhanced Bioremediation of Halogenated Aliphatic Hydrocarbons* (Parsons Engineering Science, Inc. [Parsons], 2000) for conducting enhanced bioremediation pilot studies at several United States (U. S.) Air Force installations.

Under contract number F41624-00-D8024, TO 11, Parsons Engineering Science, Inc. (Parsons) was retained to provide services for the U.S. Air Force Center for Environmental Excellence (AFCEE). The contract scope of services includes demonstration of the use of enhanced bioremediation via substrate injection to reduce concentrations of chlorinated solvents in groundwater and soil.

This addendum to the program health and safety plan was prepared to address the pilot study tasks at North Lobe Area of Concern 2 (North Lobe AOC-2) at Naval Air Station Fort Worth Joint Reserve Base (NAS Fort Worth JRB), the former Carswell Air Force Base, Texas. Included or referenced in this addendum are the scope of services, site-specific description and history, project team organization, hazard evaluation of known or suspected chemicals, evaluation of physical hazards, emergency contact information, levels of protection, and personal protective equipment. All other applicable portions of the program health and safety (HASP) plan remain in effect.

Site-specific health and safety briefings will be conducted daily prior to the commencement of field activities to communicate the site-specific hazards, activities, and procedures to all field personnel. Documentation of training and briefings, including agenda and signatures of attending personnel, will be maintained onsite.

2.0 SCOPE OF SERVICES

The scope of services to be completed by Parsons includes a technology demonstration to document the effects of organic carbon substrate addition (vegetable oil injection) on the bioremediation of chlorinated solvents in groundwater. The main tasks of the pilot study include use of a Geoprobe® direct-push rig for soil sampling and the installation of soil vapor monitoring wells, groundwater monitoring wells, and substrate injection wells; soil gas and groundwater sampling; aquifer testing; and the injection of food-grade vegetable oil into the groundwater.

3.0 SITE DESCRIPTION AND HISTORY

The descriptions, history, and maps for the site are contained in the work plan entitled *Final Work Plan for the Technology Application for Enhanced In Situ Bioremediation of Chlorinated Aliphatic Hydrocarbons via Organic Substrate Addition for Area of Concern 2, Naval Air Station Fort Worth Joint Reserve Base, Texas* (Parsons, 2003).

4.0 PROJECT TEAM ORGANIZATION

The project team assigned to the field activities at NAS Fort Worth JRB is identified below.

Mr. Bruce Henry	Project Manager
Mr. Dan Griffiths	Site Manager
Ms. Allison Love	Site Health and Safety Officer
Mr. Dan Griffiths	Alternate Site Health and Safety Officer
Mr. Mike Dodyk	NAS Fort Worth JRB Site Contact

5.0 HAZARD EVALUATION

5.1 Chemical Hazards

Potential chemical hazards are addressed in the program health and safety plan. Site-specific hazards are identified below.

The contaminants of concern at AOC 2 are the chlorinated solvents tetrachloroethene, trichloroethene (TCE), 1,1-dichloroethene (1,1-DCE), 1,2-DCE, and vinyl chloride (VC). Health hazard qualities for these and other compounds are presented in Table 5.1 at the end of this addendum.

If additional compounds are discovered during the course of field activities, this health and safety plan addendum shall be amended and pertinent information about the compounds will be communicated to all field personnel. Material Safety Data Sheets (MSDSs) for calibration gases for air monitoring instruments (see Section 11 of the Program HASP) will need to be filed onsite for reference to safety hazards and storage criteria.

5.2 Physical Hazards

Potential physical hazards at this site include risks associated with Geoprobe[®] drilling activities; motor vehicles; overhead utilities; underground utilities; slip, trip, and fall hazards; and heat/cold exposure. Since work will be conducted within the alert apron, flight line issues such as noise, ground traffic, and security will be of great concern to field personnel. Field personnel will carefully follow the instructions of all military escorts, and ear plugs and/or muffs will be worn at all times.

Safe work practices related to the site physical hazards are contained in Sections 5 and 9 of the program health and safety plan, and below.

5.2.1 Hazards Associated with the Geoprobe[®] Unit

The Geoprobe[®] unit consists of a hydraulically-driven press mounted on the bed of a pick-up truck, with power supplied to the cylinder via a power-take-off on the truck. A list of safety instructions provided by the Geoprobe[®] manufacturer is provided below, and will be followed by all Parsons and subcontractor personnel.

- **Operator must verify that underground and above-ground utility clearances have been obtained.**
- Never operate the controls without proper training.
- Orient operator cross-wind to minimize exposure to contaminants and vehicle exhaust.
- Always take the vehicle out of gear and set the emergency brake before engaging the remote ignition.
- If the vehicle is parked on a loose or soft surface, do not fully raise the rear of the vehicle with the probe foot, as the vehicle may fall or move, causing injury.
- Always extend the probe unit out from the vehicle, and deploy the foot to clear the vehicle roofline before folding the probe unit out.
- Operators must wear approved steel-toed shoes, and keep feet clear of the probe foot.
- Wear safety glasses, hardhat, and hand protection at all times during the operation of this machine.
- Wear earmuffs or disposable foam earplugs when in the vicinity of the operation of equipment, aircraft noise or other sources of high intensity noise.
- Only one person should operate the probe. Additional personnel may be necessary to assemble/disassemble the probe rods and accessories.
- Never place hands on top of a rod while it is under the machine.
- Turn off the hydraulic system while changing rods, inserting the hammer anvil or attaching accessories.
- While operating the controls, the operator must stand to the control side of the probe, clear of the probe foot and mast.
- Never exert down pressure on the probe rod so as to lift the probe foot over six inches off the ground.
- Be aware of height limitations in parking structures and around utility lines.
- Use only approved equipment, tools, and accessories for the Geoprobe®.

5.3 BIOLOGICAL HAZARDS

Various biological hazards may be encountered AOC 2. These hazards include snakes; scorpions; pathogenic organisms or diseases such as Hantavirus, Bubonic Plague, Equine Encephalitis, and Lyme Disease. Other biological hazards include insects, spiders, and cactuses or other harmful plants (such as poison ivy). Sturdy work clothes and shoes will be worn by field personnel to help prevent injuries.

5.3.1 Venomous Snakes

The prairie rattlesnake is a venomous snake that may be encountered at some sites. It is brownish or greenish brown with blotches of variable shape bordered with white along their backs. It ranges in length from three to five feet. These snakes are not particularly aggressive and inhabit fields, pine habitats, sandy areas, cultivated land, forests, rocky slopes, and along streams. They are active at night on or near paved roads.

Some rattlesnakes, such as the eastern diamondback rattlesnake do not always rattle before striking. These snakes are up to six feet long with brown, black, and beige diamond marks on their backs. They typically live in old animal burrows in forests near palmetto bushes, but can also live near fresh or salt water.

Rattlesnakes often seek cover under rocks, shrubs, and logs. Personnel should check carefully before sitting down in these types of areas, and never place hands or feet where they are not easily seen.

The cottonmouth or water moccasin has a thick body, typically two to four feet long. It is light brown with black and olive patterns when young, and all black when older. It has no rattle, is aggressive, and may strike several times. It typically lives near fresh-water swamps, lakes, streams, and ditches.

Coral snakes are skinny and approximately two feet long, and have black noses and distinguishing rings of red, yellow, and black along their bodies. They do not have long fangs, and actually chew on a person to inject venom. While other snakes make look like coral snakes, the coral snakes have red and yellow colorations touching, while the non-poisonous snakes have red and black colorations touching.

The bite of a venomous snake is extremely painful and swells rapidly. It is usually marked by one or more puncture marks created by the fangs. Skin discoloration may occur within hours. Also common are weakness, sweating, faintness, nausea, tender lymph nodes, and tingling or numbness of the tongue, mouth, or scalp. The victim should be transported to the hospital as quickly as possible. First aid should consist of keeping the victim as calm and immobile as possible, preferably lying down, and immobilizing the bitten extremity, keeping it at or below heart level to slow the spread of any poison through the body. Do not cut the wound, apply a tourniquet, or use a snakebite kit. Cold therapy is not recommended, nor is alcohol, sedatives, aspirin, or any medicine containing aspirin. Transport the victim to the hospital as soon as possible. If possible (without undo risks to personnel), obtain the snake for identification purposes.

5.3.2 Insect/Arachnid Bites and Stings

Poisonous insects and insect-like creatures at some sites may include red fire ants, bees (honeybees, bumble bees, wasps, and hornets), mosquitoes, spiders, and scorpions.

Red fire ants may be observed, especially in the vicinity of existing monitoring wells. Do not stand on, place equipment on, or otherwise disturb the anthills. It is also advisable to place a four-foot square piece of plywood where personnel need to stand. An insect repellent may be used if it does not interfere with the desired sampling

analyses. Tyvek® suits can be worn or latex booties can be taped at the top to the pants of field personnel. Frequent self-checks for crawling ants should also be performed.

Mild insect stings and bites should be treated by applying a baking soda paste or ice wrapped in a wet cloth. Do not pull out stingers with tweezers or your fingers. Stingers should be gently scraped from the skin, working from the side of the sting, using your fingernail, the edge of a credit card, a dull knife blade, or other straightedge object.

Equine encephalitis, an inflammation of the brain, can be carried by mosquitoes. Symptoms range from none to mild, flu-like symptoms (fever, headache, sore throat) to rare infection of the central nervous system with sudden fever and severe headaches followed quickly by seizures and coma. In the more severe variety, the mortality rate is up to 60%, with permanent brain damage in many of the survivors. Field personnel must wear long-sleeved clothing and/or use DEET-containing insect repellents if they are working in areas of mosquito infestations.

West Nile virus is spread by the bite of an infected mosquito, and can infect people, horses, many types of birds, and some other animals. Most people who become infected with West Nile virus will have either no symptoms or only mild ones. On rare occasions, West Nile virus infection can result in a severe and sometimes fatal illness known as West Nile encephalitis (an inflammation of the brain). The risk of severe disease is higher for persons 50 years of age and older. There is no evidence to suggest that West Nile virus can be spread from person to person or from animal to person.

Human illness from West Nile virus is rare, even in areas where the virus has been reported. The chance that any one person is going to become ill from a mosquito bite is low. You can further reduce your chances of becoming ill by protecting yourself from mosquito bites. To avoid mosquito bites, apply insect repellent containing DEET (N,N-diethyl-meta-toluamide) when you're outdoors. When possible, wear long-sleeved clothes and long pants treated with repellents containing permethrin or DEET since mosquitoes may bite through thin clothing. Do not apply repellents containing permethrin directly to exposed skin. If you spray your clothing, there is no need to spray repellent containing DEET on the skin under your clothing. Also, consider staying indoors at dawn, dusk, and in the early evening, which are peak mosquito biting times.

The two poisonous spiders likely to be encountered are the Brown Recluse and the Black Widow. They are usually found in buildings, utility box or monitoring well covers, or piles of debris, rocks, wood, or leaves. These spiders are typically non-aggressive, and bite only when disturbed. The Brown Recluse is up to one inch long with a violin or “fiddle” shaped mark on the top of the head. It is generally brown, but more poisonous varieties may be pale-brown, reddish-brown, orange, or gray. The Black Widow is a smaller, bulbous black spider with a red or yellow hourglass-shaped mark on the underside. It weaves shapeless diffuse webs in undisturbed areas.

Persons who are believed to have been bitten by a Brown Recluse or Black Widow spider should be immediately transported to a hospital. The spider should be collected for confirmation of the species.

Reactions to a Brown Recluse spider bite may be nothing, immediate, or delayed, depending upon the sensitivity of the person bitten and the amount of venom injected. A small white blister often occurs at the bite site surrounded by a swollen area. Within 24 to 36 hours, the victim may experience fever, chills, restlessness, weakness, nausea, and joint pain. Within 24 hours, the bite site can erupt into a “volcanic lesion”, which produces a hole in the flesh due to damaged gangrenous tissue. The open wound may range in size from an adult thumbnail to the span of a hand, with recovery taking months, and sometimes requiring plastic surgery and skin grafts.

Reactions to a Black Widow spider include intense pain at the site of the bite after approximately 15 to 60 minutes, followed by profuse sweating, rigid abdominal muscles, muscle spasms, breathing difficulty, slurred speech, poor coordination, dilated pupils, and generalized swelling of face and extremities. Death may occur due to complications, but usually not from the bite itself.

Contrary to popular belief, the tarantula is harmless to humans, with a bite similar to a bee sting, producing mild to moderate pain and slight swelling. It is tan or brown to black in color, and is typically nocturnal.

There are several types of scorpions native to the United States. Scorpions may be brown to yellowish in color, and range from 1/2 inch to 8 inches in length. Their bodies are divided into two parts: a short, thick upper body, and a long abdomen with a six-segment tail. A scorpion has six pairs of jointed appendages: one pair of small pincers, one pair of large claws, and four pairs of jointed legs. They are most active at night. A scorpion sting is very painful, but usually will not result in death.

If insect/arachnid stings or bites become red or inflamed or symptoms such as nausea, dizziness, shortness of breath, appear, medical care will be sought. Apply antiseptic solution to prevent infection, and ice packs to relieve swelling. Immediate care is needed if a person is allergic to insect bites/stings. Personnel with insect allergies should inform the Project Manager, Site Manager, Project Health and Safety Officer, and Site Safety and Health Officer (SSHO). If an allergic person receives a spider bite or insect bite/sting, seek immediate medical attention, keep the victim calm, and check vital signs frequently. Rescue breathing should be given if necessary to supply oxygen to the victim. The victim may experience swelling of the breathing passageways. If this occurs, the person providing the rescue breathing may have to slightly increase the air pressure to ensure that the victim receives an adequate supply of air.

5.3.3 Ticks

The primary hazards associated with ticks are Lyme disease and Rocky Mountain Spotted Fever. In the southeastern United States, Lyme disease is transmitted by the Deer Tick. This tick is very small (about the size of this asterisk: *), is red in color, and has black legs. Transmission of Lyme disease is most likely in late spring, summer, and early fall.

There are three stages of Lyme disease, although not everyone will proceed through all the stages or experience all the symptoms. The initial symptoms may include a red rash that is circular and blotchy and expands around the tick bite, and flu-like symptoms

such as fatigue, headaches, fever, swollen glands, and stiffness and pain in muscles and joints. The next stage can occur from a few days to a few weeks after the initial stage. Symptoms of this phase may include irregular heartbeat, facial paralysis, joint pain, irritability, headaches, dizziness, poor coordination, weakness, severe fatigue, and memory loss. The third stage may occur weeks to years after the second stage. Arthritis, often in the knees, is the most common symptom of this stage. The arthritis may disappear and recur many times, and chronic arthritis may develop.

People get Rocky Mountain spotted fever from the bite of an infected tick or by contamination of the skin with the contents of an attached tick when it is removed from the skin. Rocky Mountain spotted fever is spread from person to person, except rarely by blood transfusion. People with Rocky Mountain spotted fever get a sudden fever (which can last for 2 or 3 weeks), severe headache, tiredness, deep muscle pain, chills, nausea, and a characteristic rash. The rash might begin on the legs or arms, can include the soles of the feet or palms of the hands, and can spread rapidly to the trunk or the rest of the body. Symptoms usually begin 3 to 12 days after a tick bite.

If found crawling on a person, ticks should be removed and burned or smashed between two rocks. Do not smash ticks with fingers. If a tick is found to be holding onto the skin, the tick should be covered with Vaseline until it can no longer breathe and backs out of the skin. At that time, all parts of the tick should be removed with tweezers. Areas of the skin where the tick may have crawled, as well as bite area will be scrubbed with soap and water. Hot showers are to be taken as soon as possible after site departure to wash away all ticks that have not adhered to the skin. Prompt medical treatment with antibiotics is usually successful in preventing further complications from Lyme disease. Lyme disease becomes more difficult to treat the longer treatment is delayed. .

To prevent tick bites, it is recommended that DEET (vapor-active repellent) be applied to any exposed skin surface (except lips and eyes), and apply permethrin repellent spray to field clothing. It should be noted that the permethrin repellent should be allowed to dry on the clothing before putting the clothing onto the body. This combination of deet and permethrin provides the maximum protection from ticks. Long-sleeved shirts with snug collar and cuffs, pants tucked into socks, and personal protective equipment will offer some protection. Personnel should perform self-checks for ticks at the end of each workday

5.3.4 Fleas

Bubonic plague is a bacterial disease that is spread to humans by fleas that have bitten an infected animal. Bubonic plague displays symptoms rapidly. Chills and fever are soon accompanied by swelling of the lymph nodes, usually on one side of the body. These painful swellings are usually dark blue to black, hence the other common name for this disease, "black death." The disease is treatable with antibiotics. Field personnel must wear Tyvek® suits with leg seams taped to boots or boot covers to minimize contact with fleas while working in prairie dog towns.

5.3.5 Rodents

Hantavirus has been reported from the “Four Corners” area of the southwestern U.S. The Four Corners strain of Hantavirus has had a 60 percent mortality rate. Deer mice are the primary reservoir for the virus. The virus is excreted in mouse feces, urine, and saliva. People become infected when the virus is inhaled, through breaks in the skin, by ingesting contaminated food or water, or by being bitten by an infected rodent.

The incubation period for Hantavirus may be three days to six weeks. Symptoms include fever, chills, headache, dizziness, muscle aches, dry cough, nausea, vomiting, abdominal cramps, diarrhea, and shortness of breath. Progression of the disease leads to fluid in the lungs, heart irregularities, and kidney failure. Personnel will use HEPA-equipped air-purifying respirators when working in rodent-infested areas or when entering sheds of buildings containing mice infestations.

Small rodents, called nutria, have also been observed at some sites. Resembling beavers with round tails, these animals have created an abundance of burrows that provide a tripping hazard for field personnel. Care must be taken when walking in grassy areas to avoid tripping or twisting of ankles and knees.

5.3.5 Poisonous/Spiny Plants

The majority of skin reactions following contact with offending plants is allergic in nature and is characterized by general symptoms of headache and fever, itching, redness, and a rash.

Some of the most common and severe allergic reactions result from contact with plants of the poison ivy group, including poison oak and poison sumac. Such plants produce a severe rash characterized by redness, blisters, swelling, and intense burning and itching. The victim also may develop a high fever and may be very ill. Ordinarily, the rash begins within a few hours after exposure, but it may be delayed for 24 to 48 hours.

The most distinctive features of poison ivy, poison oak, and poison sumac are their leaves. Poison ivy is a woody vine whose leaves are divided into three leaflets. Poison oak is a low branching shrub with leaflets also in threes. Poison sumac is a shrub or small tree occurring in swamps. Poison sumac has 7 to 13 leaflets that resemble those of green ash trees. In certain seasons, all three plants also have greenish-white flowers and berries that grow in clusters.

A person experiencing symptoms of poison ivy or poison oak should remove contaminated clothing; wash all exposed areas thoroughly with soap and water. Apply calamine or other poison ivy/oak/sumac lotion if the rash is mild. Seek medical advice if a severe reaction occurs, or if there is a known history of previous sensitivity. Oak/ivy/sumac cleanser can be used after site work or after potential exposure to reduce chances of irritation. Personnel must wear Tyvek® suits or other protective clothing when working in areas containing these plant species.

The star thistle plant is a gray-green to blue-green plant with yellow or pale purple thistle-like flowers with sharp spines, and grows to heights varying from six inches to

five feet. The blooming period is typically from May to June. The star thistle is poisonous to horses when ingested, but is harmless to humans except for the spiny nature of the plants, which can result in scratches and lacerations. Personnel are advised to wear sturdy work clothes including long-sleeved shirts and heavy work gloves as necessary.

Cactuses and other non-poisonous spiny or thorny plants may also be common at the various installations. Personnel are advised to wear sturdy work clothes, including long-sleeved shirts and heavy work gloves as necessary to protect against skin punctures.

6.0 EMERGENCY RESPONSE PLAN

Emergency response protocols are provided in Section 6 of the Program HASP. Accident reporting requirements are specified on Page 6-3 of the Program HASP. Appendix B of the Program HASP contains the Parsons accident report form, which must be completed following an accident. Site-specific emergency response information is outlined below.

6.1 Emergency Information

Listed below are the names and telephone numbers for medical and emergency services in the event of any situation or unplanned occurrence requiring assistance. For emergency situations, telephone or radio contact should be made with the site point of contact or site emergency personnel who will then contact the appropriate response team. A list of emergency contacts must be posted at the site.

Contingency Contacts

Telephone Number

Emergency Services	911
Fire Department	911 or (817) 782-6330
On-base mobile for fire Department or Ambulance	(817) 782-6330
Poison Control Center	(800) 222-1222
Site Contact: Mike Dodyk	(817) 782-7169
AFCEE Contact: Don Ficklin	(210) 536-5290

Medical Emergency

Ambulance	911 or (817) 922-3150
Hospital Name	Harris Methodist Fort Worth Hospital
Hospital Address	1301 Pennsylvania Avenue, Fort Worth, Texas
Hospital Telephone Number	911 or (817) 882-2000

Directions to Hospital from AOC 2:

Exit NAS Fort Worth JRB to the south toward the East-West Freeway (Interstate 30). Follow signs for I-30 East. Follow I-30 for approximately 7 miles to the exit for Henderson Street. At Henderson Street, turn left (south). Follow to Pennsylvania Avenue and turn right (west). Continue one block and turn left (south) onto Fifth Avenue. The entrance is located on the right.

Parsons Contacts

Telephone Number

Bruce Henry Parsons Project Manager	(303) 831-8100 or 764-1986 (W) (303) 422-4019 (H)
Timothy Mustard, C.I.H. Program Health and Safety Manager (Denver)	(303) 831-8100 or 764-8810 (W) (303) 450-9778 (H)
Ed Grunwald, C.I.H. Corporate Health and Safety Manager (Atlanta)	(678) 969-2394 (W) (404) 299-9970 (H)
Judy Blakemore Asst. Program Health and Safety Manager (Denver)	(303) 831-8100 or 764-8861 (W) (303) 831-4028 (H) (303) 817-9743 (M)
Parsons 24-Hour Emergency Contact Service	(866) 727-1411 (toll free)

7.0 LEVELS OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR SITE ACTIVITIES

The personal protection level prescribed for field activities at NAS Fort Worth JRB is Occupational Safety and Health Administration (OSHA) Level D with a contingency for the use of OSHA Level C or B, as site conditions require. The following will be used to select respiratory protection at AOC 2.

If sustained air-monitoring readings in the worker-breathing zone indicate vapor concentrations greater than background for 30 seconds or longer, the field crew will be forced to evacuate and ventilate the area until readings are less than 1 part per million (ppm) in the worker-breathing zone. If ventilation is inadequate, air samples will be taken to confirm or deny the existence of the contaminants of concern and/or the crew will upgrade to Level B respiratory protection. These air samples will be sent to a lab to be analyzed by US Environmental Protection Agency (USEPA) Compendium Method TO-14 or the equivalent. Decisions for further actions and for levels of respiratory protection will be made after consulting with the project manager and program health and safety manager.

Section 7 of the Program HASP contains guidelines for selection of PPE. PPE will be required when handling contaminated samples and when working with potentially contaminated materials. See Page 7-4 of the HASP for PPE to be used.

8.0 FREQUENCY AND TYPES OF AIR MONITORING

A photoionization detector (PID) with an 10.6 electron volts (eV) (HNU®) or equivalent lamp will be used for air monitoring during this project since the ionization potentials of the contaminants of concern are below 10.6 eV.

Section 7 of the Program HASP contains guidelines for selection of PPE. PPE will be required when handling contaminated samples and when working with potentially contaminated materials. See Page 7-4 of the HASP for PPE to be used.

TABLE 5.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN

Compound	PEL ^{a/} (ppm)	TLV ^{b/} (ppm)	IDLH ^{c/} (ppm)	Odor Threshold ^{d/} (ppm)	Ionization Potential ^{e/} (eV)	Physical Description/Health Effects/Symptoms
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA ^{f/}	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acrid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.
Tetrachloroethene (PCE) (Perchlorethylene)	25 ^{g/}	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Vinyl Chloride	1 (29 CFR 1910.1017) ^{h/}	1	NA	260	9.99	Colorless gas (liquid<7°F) with a pleasant odor at high concentrations. Severe irritant to skin, eyes, and mucous membranes. Causes weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, Also attacks lymphatic system. Mutagen, experimental teratogen, and carcinogen.

a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997. Some states (such as California) may have more restrictive PELs. Check state regulations.

b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), 2001 *TVLs® and BEIs®*.

c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997.

d/ When a range is given, use the highest concentration.

e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.

f/ NA = Not available.

g/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.

h/ Refer to expanded rules for this compound.

APPENDIX C

AQUIFER TEST METHODS

C-1 CONVENTIONAL SLUG TESTING

AQUIFER TEST BY METHOD OF WILSON (1997)

Initially, the water level in each groundwater monitoring point is measured. Then, a 0.25-inch OD polyethylene tube is inserted into the well and the protruding portion of this tube is fitted to flexible tubing designed for application with a high-flow peristaltic pump. If the monitoring well has not been developed, the pump should be used to develop the well prior to conducting the test. After the well has been developed, time should be allotted to allow the water level to recover to its starting elevation.

Each conductivity test is performed at a single depth below the water table elevation. However, depending on the well yield, several depths may be evaluated. To perform each test, the tube is inserted to the prescribed depth and the pump is started. The well is then pumped until the well has been dewatered to the end of the tubing and an air-water mixture observed at the pump discharge. The pump speed is adjusted to balance the pumping rate with the groundwater infiltration rate, thereby maintaining a constant drawdown in the well and a visible air-water mixture. By continuing to pump at this rate, a quasi-equilibrium is established in the well. After equilibrium has been established, pumping the well is continued into a measured vessel and the time required to collect 100 ml is recorded. For low-yielding wells, record the volume of water collected for a prescribed amount of time (e.g., five minutes). Calculate the specific capacity in units of milliliters per second per centimeter (ml/sec-cm) of drawdown. This method is called an inverse specific capacity test because the drawdown is set and the flow rate is varied (Wilson et. al., 1997).

C-2 SINGLE WELL AQUIFER TESTS

AQUIFER TESTING

CONVENTIONAL SLUG TESTING

Aquifer testing (slug tests) are conducted before and after oil injection to estimate the hydraulic conductivity of unconsolidated deposits at the site and to estimate the impact of oil injection. A slug test is a single-well hydraulic test used to determine the hydraulic conductivity of an aquifer in the immediate vicinity of the tested well. Slug tests can be used for both confined and unconfined aquifers that have a transmissivity of less than 7,000 square feet per day (ft²/day). Slug testing can be performed using either a rising head or a falling head test; at this site, both methods will be used in sequence.

Definitions

- **Hydraulic Conductivity (K).** A quantitative measure of the ability of porous material to transmit water; defined as the volume of water that will flow through a unit cross-sectional area of porous or fractured material per unit time under a unit hydraulic gradient.
- **Transmissivity (T).** A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and the saturated thickness of the water-bearing zone.
- **Slug Test.** Two types of tests are possible: rising head and falling head. A slug test consists of adding a slug of water or a solid cylinder of known volume to the well to be tested or removing a known volume of water or cylinder and measuring the rate of recovery of water level inside the well. The slug of a known volume acts to raise or lower the water level in the well.
- **Rising Head Test.** A test used in an individual well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the well and measuring the rate of recovery of the water level. The water level may be lowered by pumping, bailing, or removing a submerged slug from the well.
- **Falling Head Test.** A test used in an individual well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the well by insertion of a slug or quantity of water, and then measuring the rate of drop in the water level.

Equipment

The following equipment will be used to conduct a slug test:

- Decontaminated Teflon[®], PVC, or metal slugs or bailers;
- Nylon or polypropylene rope;

- Electric water level indicator;
- Pressure transducer/sensor;
- Field logbook/forms; and
- Automatic data recording instrument (such as the Hermit Environmental Data Logger[®], In-Situ, Inc. Model 3000, or equivalent).

General Test Methods

Aquifer hydraulic conductivity tests (slug tests) are accomplished by either removal of a slug or quantity of water (rising head) or introduction of a slug (falling head), and then allowing the water level to stabilize while taking water level measurements at closely spaced time intervals. It is assumed that the wells were properly developed and that water levels have stabilized. Slug testing will proceed only after water level measurements show that static water levels are in equilibrium. During the slug test, the water level change should be influenced only by the introduction (or removal) of the slug volume. Other factors, such as inadequate well development or extended pumping, may lead to inaccurate results. The pressure transducer, slugs, and any other downhole equipment will be decontaminated prior to and immediately after the performance of each slug test.

Falling Head Test

The falling head test is the first step in the two-step slug testing procedure. The following steps describe procedures to be followed during performance of the falling head test.

1. Decontaminate all downhole equipment prior to initiating the test.
2. Open the well. Where wells are equipped with watertight caps, the well should be unsealed at least 2 hours prior to testing to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.
3. Prepare the aquifer slug test data form with entries for:
 - Borehole/well number,
 - Project number,
 - Project name,
 - Aquifer testing team,
 - Climatic data,
 - Top of well casing elevation,
 - Identification of measuring equipment being used,
 - Static water level, and
 - Date.

4. Measure the static water level in the well to the nearest 0.01 foot.
5. Lower the decontaminated pressure transducer into the well and allow the displaced water to return to its static level. This can be determined by periodic water level measurements until the static water level in the well is within 0.01 foot of the original static water level.
6. Lower the decontaminated slug into the well to just above the water level in the well.
7. Turn on the data logger and quickly lower the slug below the water table, being careful not to disturb the pressure transducer. Follow the owner's manual for proper operation of the data logger.
8. Terminate data recording when the water level stabilizes in the well. The well will be considered stabilized for termination purposes when it has recovered 80 to 90 percent from the initial displacement.

Rising Head Test

After completion of the falling head test, the rising head test will be performed. The following steps describe the rising head slug test procedure:

1. Measure the water level in the well to the nearest 0.01 foot to ensure that it has returned to the static water level.
2. Initiate data recording and quickly withdraw the slug from the well. Follow the owner's manual for proper operation of the data logger.
3. Terminate data recording when the water level stabilizes in the well, and remove the pressure transducer from the well and decontaminate. The well will be considered stabilized for termination purposes when it has recovered 80 to 90 percent from the initial displacement.

Slug Test Data Analysis

Data obtained during slug testing will be analyzed using the method of Cooper *et al.* (1967) for confined aquifers, or the method of Bouwer and Rice (1976) and Bouwer (1989) for unconfined conditions.

C-3 AQUIFER TEST BY METHOD OF WILSON (1997)

DRAFT TECHNICAL M E M O R A N D U M

July 10, 2000

To: Todd Wiedemeier and Kent Boulicault, Parsons ES

From: Bruce Henry, Parsons ES

Subject: Single Well Aquifer Tests

This memorandum describes a single well test protocol for hydraulic conductivity using groundwater pumping. This test protocol is designed to be used with small diameter well casings (1.0- or -.75-inch inside diameter) where use of a slug is not practical. This protocol may also be used with larger diameter wells with low hydraulic conductivity. The primary disadvantage compared to conventional slug testing is the production of groundwater investigation-derived waste (IDW).

SINGLE WELL AQUIFER TEST METHODS

The following is a list of single well tests and analytical solutions. Descriptions of these analytical solutions can be found in *Analysis and Evaluation of Pumping Test Data* by G.P. Kruseman and N.A. deRidder, 1990. Groundwater Software sells a Single Well Solutions software package for the following tests for approximately \$300.

- **Slug Test** – Bouwer and Rice, 1976; Cooper *et al.*, 1967
- **Constant Discharge Test** – Hurr and Worthington, 1981; Hantush, 1964
- **Variable Discharge** – Bisroy and Summers, 1980 (intermittent pumping); Bisroy and Summers, 1980 (uninterrupted pumping)
- **Step Drawdown** – Hantush and Bierschenk, 1964
- **Constant Discharge Recovery** – Theis, 1935

SINGLE WELL AQUIFER TEST APPROACH

The proposed single well test protocol is designed to use multiple test methods in sequence. A transducer is lowered to the screened interval of the test well and a purging line is lowered to approximately 3 feet above the transducer. Once the water level stabilizes, groundwater is pumped at constant rates until the water level again stabilizes. The resulting data can then be evaluated by analytical solutions.

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EQUIPMENT REQUIREMENTS

Equipment required includes a pressure transducer and data logger, and sample tubing attached to a peristaltic pump at the surface. The transducer must be able to fit down the well, and the transducer cable must be thin enough to allow the sample tubing to follow. The pump must be able to maintain a constant flow rate, and the well must have sufficient hydraulic conductivity to maintain a constant discharge. A scaled collection vessel is required to measure discharge over time in order to calculate flow rates. This test could also be run on deeper or larger diameter wells with constant flow submersible pumps, if feasible.

SINGLE WELL AQUIFER TEST PROTOCOL

The following protocol is based on collection of data to calculate hydraulic conductivity by 1) Constant Drawdown, 2) Step Drawdown, and 3) Constant Discharge Recovery. The first step in a step drawdown test can be run as a single constant drawdown test. The last step of a step drawdown test can be run until drawdown is steady (constant), which then allows for a constant discharge recovery test.

The step by step protocol is as follows:

Phase 1 – Constant Drawdown

- 1) Decontaminate the transducer, transducer cable, and sample tubing.
- 2) Lower the transducer to the screened portion of the well, if possible. Note that the hydrostatic gradient of fresh water is approximately 0.433 pounds per square inch (psi) per foot. Therefore, a 10-psi transducer should not be lowered more than approximately 20 feet below the static water level. Otherwise a larger capacity transducer should be selected.
- 3) Lower the sample tubing to approximately three feet above the pressure transducer.
- 4) Monitor the transducer level until steady, set as zero reference.
- 5) Start the data logger and then the pump at a relatively low rate.
- 6) Record the volume pumped over time to calculate the flow rate. Repeat the flow rate measurement to verify.
- 7) Monitor the data logger until the water level stabilizes to within 0.1 foot, and record the test time at which steady state was maintained over several minutes.

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Continue to run the test for several more minutes. It is possible the water level may start to rise due to transient effects.

Phase 2 – Step Drawdown

- 8) Increase the flow rate by approximately 30 percent, and measure the new pump flow rate. Repeat the flow rate measurement to verify.
- 9) Monitor the data logger until the water level stabilizes to within 0.1 foot, and record the test time at which steady state was maintained over several minutes.
- 10) Repeat steps 7 and 8.
- 11) Repeat steps 7 and 8.
- 12) After step 10, Monitor the data logger until the water level stabilizes to within 0.05 foot, and record the test time at which steady state was maintained, and allow the well to pump at a constant discharge rate for approximately 15 minutes.

Phase 3 – Constant Drawdown Recovery

- 12) Note the test time on the data logger and turn off pump.
- 13) Monitor data logger until well recovers to within 90 percent of the initial static water level, or for a reasonable time-frame not to exceed 20 minutes..

Pumping rates and the duration for each phase will need to be adjusted in the field based on the properties of the aquifer. If the well is slow to stabilize, resulting in an excessively long test, then Phase 2 (Steps 7 through 11) can be skipped from the test protocol, with only the constant drawdown and constant drawdown recharge methods used to calculate hydraulic conductivity.

SINGLE WELL AQUIFER TEST ANALYSIS

Well test drawdown versus time is used as input into the appropriate analytical solutions. The data may have to be separated at the appropriate times for each test method. The constant drawdown data (Phase 1) can be used as the first step of the step drawdown test.

APPLICATION OF TEST METHODS

These methods can be applied to confined and unconfined conditions, although a correction is necessary for unconfined tests. A fully functional test version of the Groundwater Software Single Well Solutions software and be downloaded for a 15-day trial at www.groundwatersoftware.com.